cycles

—A MONTHLY REPORT

February 1953

FOUNDATION FOR THE STUDY OF CYCLES
New York, New York

CONTENTS

Page

THE DIRECTOR'S LETTER 39

RESEARCH
Trends and Cycles in the Production of Rayon . . . 43

HOW IT CAME OUT
A Forecast of Viscose Filament Yarn Production . . . 61

LETTERS 63

ADDITIONS TO THE LIBRARY 66

THE FOUNDATION FOR THE STUDY OF CYCLES

The Committee of the Foundation consists of the following scientists and administrators:

UNITED STATES OF AMERICA

Copley Amory, Chairman Emeritus

Charles Greeley Abbot
Research Associate
Smithsonian Institution

Harold Elmer Anthony
Chairman and Curator
Department of Mammals
American Museum of Natural History

George Baekeland, Chairman of the
Committee of the Foundation
The Bakelite Corporation

Harold Gardiner Bowen
Vice Admiral, U.S. Navy, Retired
Executive Director, Thomas Alva
Edison Foundation

Verne Burnett
Partner
Verne Burnett Associate

Hon. W. Cameron Forbes
Member, Board of Trustees
Carnegie Institution of Washington;
Life Member of the Corporation,
Massachusetts Institute of Technology

Webster N. Jones
Dean, College of Engineering and Science
Carnegie Institute of Technology

Daniel Trembly MacDougal
Former Director
Department of Botanical Research and
Laboratory of Plant Physiology
Carnegie Institution of Washington

John Quincy Stewart
Professor of Astronomy, Physics
Princeton University

CANADA

Hon. Charles Camsell
Former Commissioner
Northwest Territories

Frank Cyril James
Principal and Vice-Chancellor
McGill University

GREAT BRITAIN

Sir Patrick Ashley Cooper
Governor
Hudson's Bay Company

Julian Sorell Huxley
Former Director General
United Nations Educational, Scientific and Cultural Organizations

Edward R. Dewey, Director

CYCLES — A Monthly Report is published by the Foundation for the Study of Cycles every month except during July and August at the Foundation's offices at 9 East 77th Street, New York 21, N. Y. Subscription rates $10.00 a year. Entered as second class matter at the Post Office at New York, N. Y. Letters for the personal attention of the Director should be sent to East Brady, Pennsylvania.

cycles
—a monthly report
The Official Bulletin of the Foundation for the Study of Cycles
VOLUME IV NUMBER 2 FEBRUARY 1953

The Director's Letter

Dear Member:

Sixteen Years of Work

Within a day or two of the time this report is due to reach you, I shall have completed sixteen years devoted almost exclusively to the study of rhythmic cycles.

As a result of this effort I have learned a little something about how to detect and isolate rhythms, and a little something more (but not very much) about the rhythms that exist in natural and social phenomena. On the other hand, I do not feel that as yet I know for certain the exact wave length of even one single cycle, or that I have more than a first crude approximation of the law that may determine what cyclic forces can or can not exist.

Convinced of Significance of Cycles

As a result of my sixteen years of work, however, I am more than ever convinced that the rhythms that have been discovered are the result of rhythmic environmental forces acting upon all living things including man, acting upon climate, and acting upon the earth itself. I conjecture that just as we are bathed in a sea of light waves of very short wave length, we may also be bathed in a sea of energy waves of longer length, undiscoverable except as disclosed by resultant behavior. Moreover, I conjecture that just as a certain object will respond to light waves of one group of wave lengths (color), and other objects will respond to light waves of another group of wave lengths, so also certain phenomena will respond to one group of these longer energy waves and other phenomena will respond to another group. If this be true we would expect to find an overlapping, with certain cycles of the same wave length common to many different series of figures; and this is exactly what we do seem to find.

Many Different Cycles

Implicit in the concept outlined above is the idea of the concurrent presence of many different cyclic forces with wave lengths very close to each other—how close we do not know yet. At first this may seem odd, but it is really no stranger than the fact that on a clear bright sunny day all of our surrounding space is filled at one and the same time with yellow light, green light, blue light, and red light, and with hundreds of gradations and combinations of each, as we can see by observing the different sorts of light reflected by different sorts of objects.

Real Cycles Combine to Create False Ones

A simple diagram (Fig. 1 on the next page) will show you that the combination of two recurring cycles of different, but not too different, wave lengths and of more or less equal strength, will result in a rhythm which, for a while, will show a false length half way between the lengths of the causative cycles. This "false" rhythm will eventually fade out. Subsequently it will reappear, but upside down.

In the paragraph above I put "false" in quotes because the rhythm is not really false. It is perfectly real—while it lasts. It is false merely in the sense that it will not continue permanently in its present form.

As an example of what I have been

saying, if you observe the combined effect of 15- and 16-month rhythmic forces of more or less equal intensity you will not be able, by inspection, to distinguish either cycle separately. You will observe merely a 15½-month behavior which will vanish and then reappear with crests where a projection of the ideal 15½-month pattern called for troughs and vice versa.

Now mark the converse of these observations applied to some particular behavior in which you are interested and which you would like to predict—let us say the stock market.

What You Must Expect to Find

First of all you must expect to find many, many rhythmic cycles in these figures (and you do).

Second, to obtain a projection that will be of practical use you must take at least a substantial number of these component rhythms into account, unless the series of figures with which you are dealing is dominated by a single cycle, as sometimes happens.

Third, you must expect that many of the observed rhythms will vanish, sooner or later, whether you go forward in time or backward, unless by rare chance the rhythm you see is not the composite effect of two or more closely related rhythmic forces, but is caused by a single rhythmic force. You know how rare it is in nature to see an absolutely pure color of a single wave length. It is the same with the cycles measured in days, weeks, months, and years, also.

The 6-Year Cycle

For example, the so-called six-year cycle, which has been coming true so beautifully since it was first discovered in 1937, more or less fades out as we go back of 1890. Presumably it will fade out in the future too, some cycles hence. If you read an article I wrote on the 6-year cycle which was published in the Winter 1951--52 Journal of Cycle Research you may remember that I said in that paper that the so called 6-year cycle in cotton prices seemed to be complex of four cycles--5.575, 5.91, 6.11, and 6.45 years in length respectively. Seemingly it is the interplay of these four cyclic tendencies, just happening, at the present time, to be more in step with each other than not, that creates, temporarily, the 6-year pattern in cotton prices, and in other things as well.

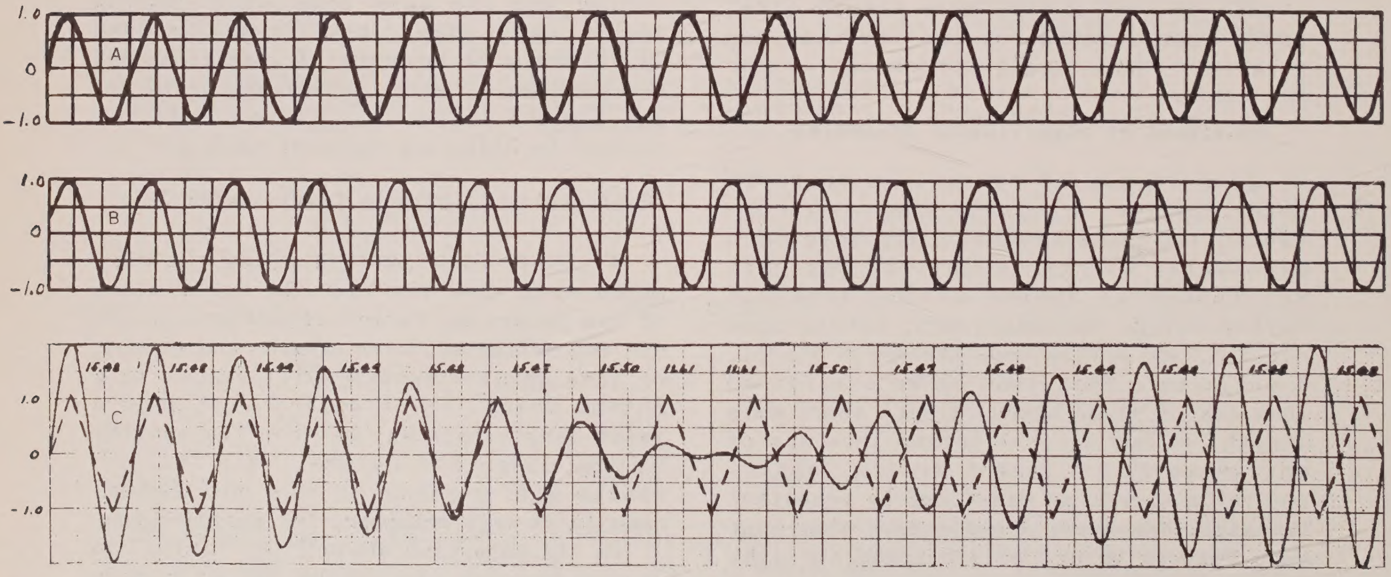


FIG. 1 CURVE A. A PERFECTLY REGULAR 16-MONTH CYCLE REPEATED 15 TIMES.
CURVE B. A PERFECTLY REGULAR 15-MONTH CYCLE REPEATED 16 TIMES.
CURVE C. THE SYNTHESIS OR COMBINATION OF CURVE A AND B TOGETHER WITH A PERFECTLY REGULAR 15½-MONTH CYCLE DIAGRAMMED BY A BROKEN ZIGZAG LINE. NOTE THAT THE COMBINED EFFECT OF CYCLES A AND B IS A 15½-MONTH CYCLE WHICH GRADUALLY FADES OUT. IT THEN REAPPEARS UPSIDE DOWN IN RELATION TO THE 15½-MONTH PATTERN.

The Task Ahead

Thus, in recurring cycles, as in almost everything else, something deeply hidden lies behind things. To find these deeply hidden underlying truths takes a great deal of slow patient probing. The necessary research is being carried on and reported upon as fast as resources permit.

One Way You Can Help

Our progress is steady, but I am impatient at its rate. Perhaps you feel the same way. If so, and if you are in a position to influence the actions of some corporation, you could be of real help both to the corporation and to the science of cycle research if you could induce the corporation to employ us to make some cycle studies for them. If, hopefully, the corporation is in the excess profit bracket, the expenditure during 1953 of $15,000 for research in regard to the behavior of their sales or of the prices of their product or of some important raw material would cost them only $2,700. This sum is peanuts for something that has even a remote possibility of usefulness. Of course the corporation executives might not wish to employ an outside agency. They might wish to conduct the research within their own organization. Self-conducted research has definite advantages. If their thoughts run along these lines they could send their statistician (perhaps you) to Foundation Headquarters so that he could do the work himself with our cooperation. (I would not however advise anyone to attempt a serious cycle analysis without first learning all that could be learned from concentrated study here.)

* * *

Error in the September Report

In connection with discovering the laws of cycle length, I would like to call attention to an error in our September 1952 report. The cycle lengths referred to in the article "Order out of Chaos" on pages 236-9 are lengths in years, not months as stated on pages 237, 238, and 239. Also, the formula on page 239 should be $N^2/49$, not $N^2/44$. If you keep back copies please correct these pages now while you think of it.

* * *

The Journal of Cycle Research

In the Director's letter for September 1952 I told you that we were planning to print the **Journal of Cycle Research** as a supplement to **Cycles--A Monthly Report**. In accordance with that plan, we did print the fall Journal as part of the November report and, until half an hour ago, had planned to print the winter **Journal** as part of the February report, the spring **Journal** as part of the April report and so on.

The **Journal** was created to serve as a clearinghouse for the scientists. If it is to maintain its standing in the scientific world, it must be written solely for scientists. The editor must be free to select and arrange material with no thought except the needs of the scientists for whom the publication is intended, regardless of how dull it might be for the general readers or how long the material might happen to be.

On the other hand, in the monthly report we must try to keep the material interesting and timely and, as far as possible, practical. Moreover, there are space limitations we must observe because of expense.

For example, for the winter **Journal** Dr. Wing wanted to publish a 36 page article on cycles in lynx abundance. I said "We can't afford to reprint as many pages as that in **Cycles**, and, even if we could, our readers don't want as big a dose of lynx as that anyway. Eight or ten pages perhaps, but 36 pages, no." Now this attitude is good from the standpoint of our contributing members, but it is certainly bad from the standpoint of the scientist who wants and needs the 36 page lynx article. And the **Journal** was created for him.

I now see that it is as incongruous for us to reprint the **Journal** entire as it would be for **Time Magazine** for example to copy verbatum in their medical section an original report from some medical journal. And as **Time** would do it, we shall use the meat of the **Journal's** technical articles as news for you in the monthly report.

Therefore, with your permission, I would like to renege on the promise to reprint the Journal entire, and to print for you in **Cycles** only such articles or parts of articles as I believe you would find of interest and value.

For example, in the present report I am reprinting an 18-page article from the winter **Journal**. Other articles from other **Journals** will be reprinted from time to time whenever I feel that the subject matter will be of interest to you, but in the future when we put the **Journal** together we are going to be thinking entirely of the needs of the scientists.

If you contributed money to the Foundation because of my promise to reprint the Journal entire, just let me know and I will send you the **Journal** free during the term of your current membership. Or, if this is not the case, but you wish to get the entire **Journal** anyway as well as the reports you can, of course, subscribe for the **Journal** separately.

* * * * * *

A Primer for Cycle Students

More than anything else I get requests for a textbook to tell how to analyze a series of figures for cycles. Someday I hope to write such a book. In the meantime, if you are interested in this aspect of the subject, you will have to pick up what you can from articles in these monthly reports, and elsewhere.

In this connection I am reprinting for you from the **Journal of Cycle Research** an article about the cycles in rayon production which should be of considerable help. Probably you do not give two hoots about rayon production. But no matter. The processes and techniques of cycle analysis are the same, be it rayon, or sales of locomotives, or the price of tin, or the fluctuations of General Motors.

I commend this article to all of you who are technically minded. It shows you just how a cycle analysis is made, complete with working charts and arithmetic. It originally sold for $100 a copy. It was intended to enable rayon producers to throw light on the probabilities of the future for their industry.

I hope you will find the article helpful in making studies of your own and in understanding better studies of this sort made by others.

* * *

Stock Market Studies Resumed

In the next report I am resuming for you the series of studies in regard to cycles in the stock market started some time ago. After a while we will be far enough along with these separate studies to combine some of the discovered cycles and project the composite into the future as a first approximation of probable future behavior.

* * *

Predix Charts to be Published

If you were a member last spring you may recall my comments in regard to an elaborate cycle analysis of stock market prices made by Mr. Vedder Hughey of Coral Gables, Florida, and published under the pseudonym of Predix. If you bought a set of these Predix charts from Mr. Hughey I am sure you are gratified, as I am, at the extent to which the market behavior since June has conformed to the Predix projections.

If you did not buy Mr. Hughey's charts and are interested in the market you will be glad to know that Mr. Hughey has given me permission to reproduce his charts in our March, April and May reports. I plan to reproduce the plates of Mr. Hughey's long term cycles in the March report, the plates of his intermediate term cycles in the April report and the plates of his short-term cycles in the May report. I am sure you will want to see Mr. Hughey's projections and watch how they work out in the future.

Cordially yours,

Edward R. Dewey

Director

TRENDS AND CYCLES IN THE PRODUCTION OF RAYON*

A STUDY OF VISCOSE** FILAMENT YARN PRODUCTION IN THE UNITED STATES, 1911--1948

By Edward R. Dewey

Summary: This paper describes the successive isolation of 2-year, 2 3/4-year, 3 1/2-year, and 5-year cycles in the production of viscose rayon filament yarn, 1911-1949. It adjusts the figures for these cycles to obtain an approximation of the underlying growth trend. It projects the cycles into the future and combines them to show the deviation from trend that will occur if the cycles continue. The paper is intended as an example of a simple cycle analysis. It includes all arithmetic so that the processes of analysis and synthesis can be followed easily.

Part I. The Data

The growth of viscose** rayon filament yarn production from its beginning in 1911 to the present time has been called one of the seven wonders of the industrial world.[1]

During the entire period under review, production failed to increase only four years (1918, 1932, 1934, and 1938). The over-all growth from 400,000 pounds in 1911 to 562,300,000 pounds in 1948 shows a gain of over a thousandfold in less than two generations. Year-by-year figures are given in Table 1 and plotted on arithmetic scale in Figure 1.

Rate of Growth Declining

If we study trends and cycles, however, it is necessary to plot the figures on ratio (or **semi-logarithmic**) scale (Figure 2).*** One advantage of such a plotting is that it shows directly the falling-off in the rate of growth, and permits making visual or freehand projections into the future that are much more likely to be reliable than would be any similar projection of a chart on ordinary arithmetic scale.

The growth of viscose rayon filament yarn production over the years has been dramatic, yet the fact that the curve no longer rises as rapidly as formerly demonstrates immediately that the rate of growth is slowing down.

Percentage comparisons substantiate this. From 1946 to 1947, for example, the production increased 6.9 percent. But from 1936 to 1937 production increased 10.8 percent; from 1926 to 1927, 17.1 percent; from 1919 to 1920, 22.0 percent; and from 1913 to 1914, 33.3 percent. (Percentage growth for each year, in comparison with the year before, is shown in Table 2.) It would be interesting to make a detailed study of the growth, but this is impossible until we have studied the cycles. Underlying growth trends can **never** be properly studied until the cycles have been determined and adjustments made to take account of them.

Four Cycles in Rayon Production

If the rayon figures are analysed for cycles or rhythms, it will be found that from the beginning the figures act as if the trend had been influenced by four well-known rhythmic forces. From crest to crest, one of these series of repetitive waves is about 2 years long, one is about 2 3/4 years long, another is about 3 1/2 years long, and still another is about 6 years long. In a sense the curve acts as if it were pushed up and down around the underlying growth trend by the composite force of these four rhythmic influences, and of course, by accidental forces, such as war.

Part II. The 2-Year Rhythm

Careful observation of Figure 2 shows that from the beginning there has been a tendency for growth to be greater in odd than in even years. For example: start in 1939 and count backwards: High, low; high, low; high (relative to trend), low; and so forth. This rhythmic tendency can be more easily seen if we insert a moving average trend line (shown by the broken line in Figure 2) and observe the years in which the production is over or under the trend. Figures for the moving average trend are given in Table 3.

Relation of Production Figures to 2-Year Trend

The 2-year rhythm can be seen even more easily if we compute the percentages that the actual figures are of the trend and plot them by themselves. Observe the solid line in Figure 3: the effect of this computation is to convert the trend into a straight horizontal line or, as it were, to pull it level. Figures for the percentages are given in Table 4.

To Figure 3 has been added, by means of a broken line, a perfectly regular 2-year wave to help follow the 2-year pattern and to help disclose those places where the 2-year wave has failed to dominate the situation. Up to the war there were three such places: production in 1916 was "too big," and in 1921 and 1927 "too little." If in those three years, other factors had not upset the 2-year pattern, the 2-year pattern would have been perfect from 1911 up to the war. The 2-year rhythm largely disappeared with the coming of the war, but even so there seems to be a vestige of it left.

The broken line in Figure 2 is a two-year moving

---

* BASED UPON A REPORT PREPARED IN MIMEOGRAPH FORM BY THE FOUNDATION FOR THE STUDY OF CYCLES IN 1949.

** WHENEVER THE WORD "VISCOSE" APPEARS IN THIS REPORT IT IS UNDERSTOOD TO INCLUDE NITROCELLULOSE PROCESS RAYON YARN UNTIL ITS PRODUCTION WAS DISCONTINUED IN 1934, AND ALSO TO INCLUDE THE PRODUCTION OF CUPRAMMONIUM FILAMENT YARN FROM ITS FIRST PRODUCTION TO DATE.

*** FOR A FULL DISCUSSION OF THE RATIO SCALE, MOVING AVERAGES, TRENDS, AND CYCLES, SEE REFERENCES 2 AND 3.

[1] THIS REFERENCE AND ALL OTHERS ARE INCLUDED AT THE END OF THE REPORT.

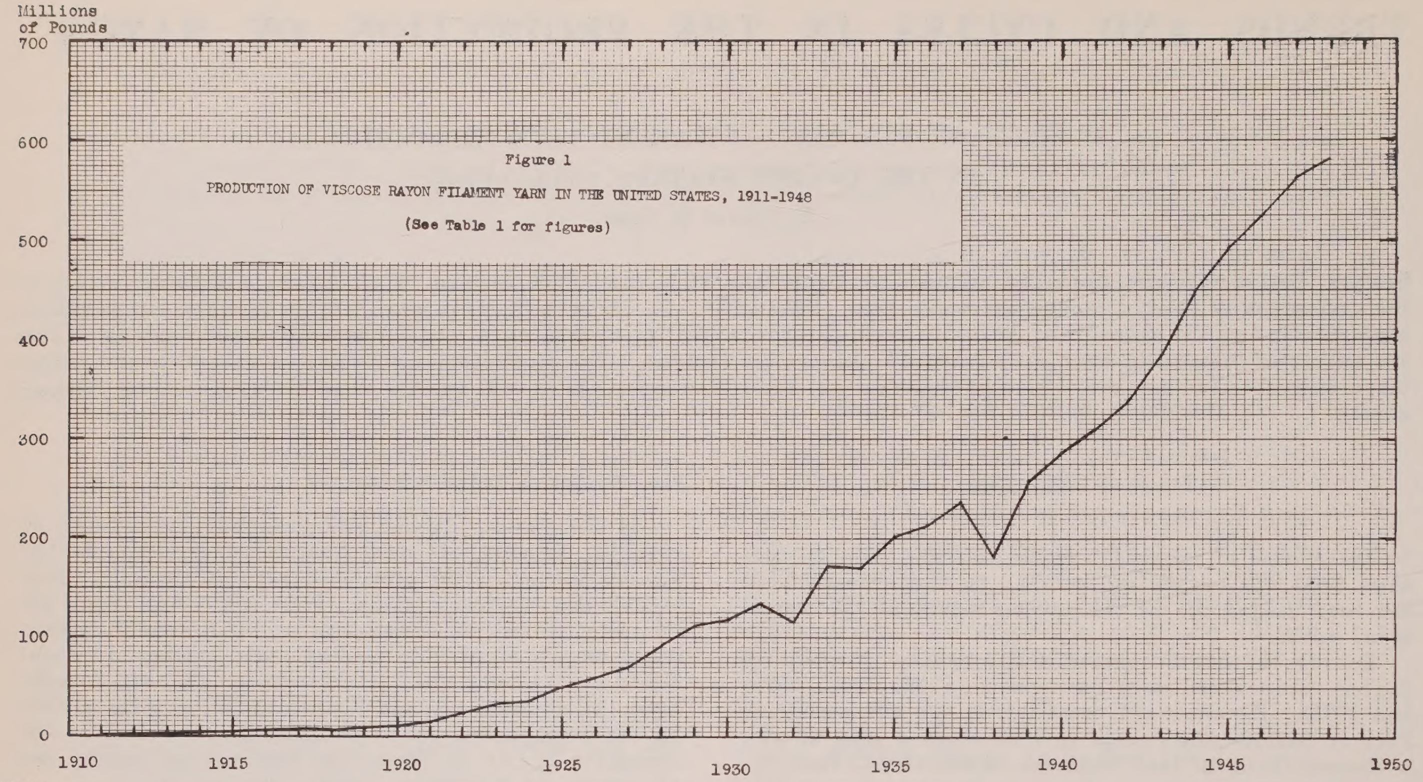


Figure 1

PRODUCTION OF VISCOSE RAYON FILAMENT YARN IN THE UNITED STATES, 1911-1948

(See Table 1 for figures)

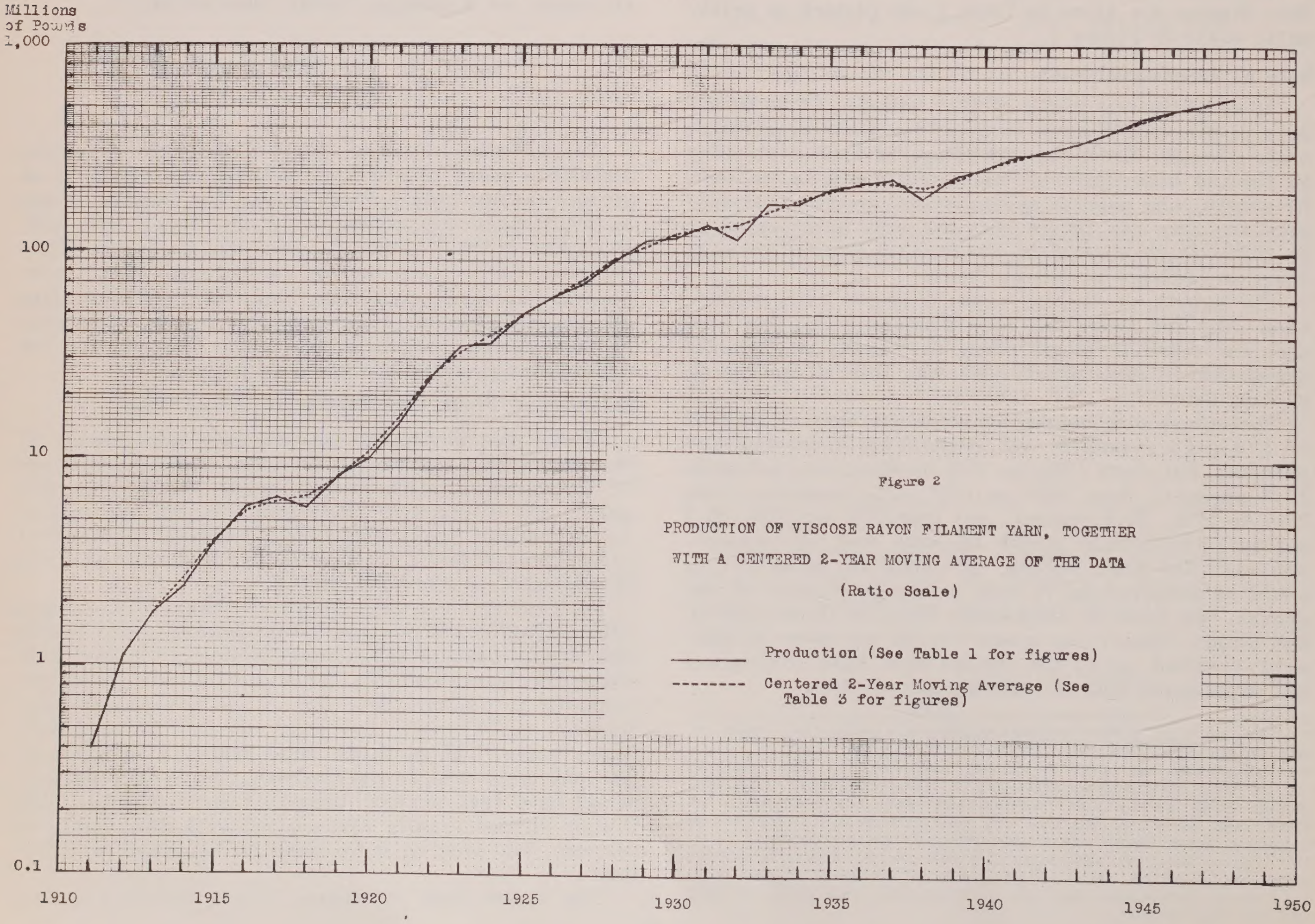


Figure 2

PRODUCTION OF VISCOSE RAYON FILAMENT YARN, TOGETHER WITH A CENTERED 2-YEAR MOVING AVERAGE OF THE DATA

(Ratio Scale)

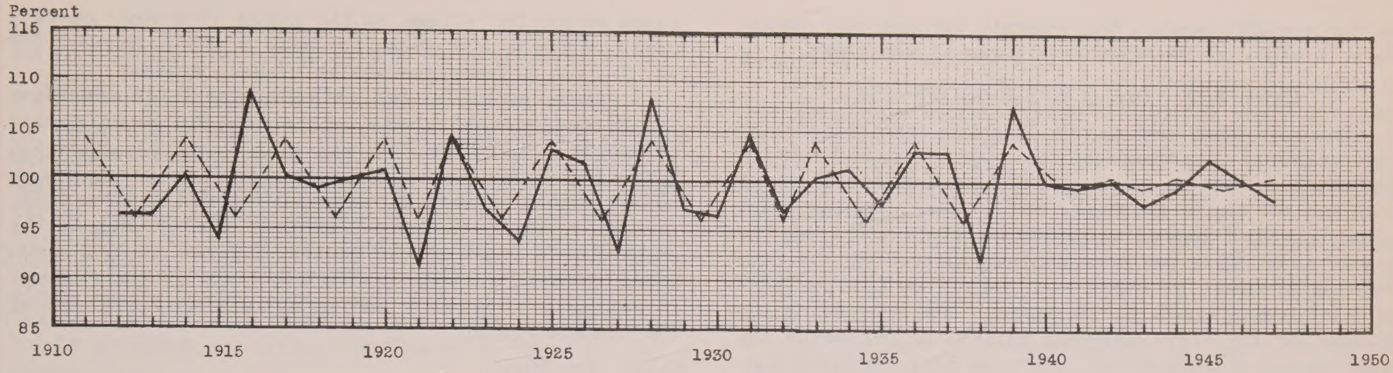


Figure 13

THE 2 3/4-YEAR RHYTHM IN THE PRODUCTION OF VISCOSE RAYON FILAMENT YARN

——— Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effects of the 2-Year, 3 1/2-Year and 6-Year Rhythms, Are of the 3-Year Moving Average of the Same.

------- Diagrammatic Representation of a Perfectly Regular Rhythm with Peaks at 3-, 3-, 3-, 2-Year Intervals, Based on 1911 and Repeating Every 11 Years.

average of a 2-year moving average. The effect of such a computation is to eliminate any 2-year wave that might be present in the original figures.[3] Then, by comparing the original figures (which have the 2-year wave still in them) with the trend (from which the 2-year waves have been smoothed out) we get the figures plotted in Figure 3, in which the 2-year wave can be seen largely by itself.

A rhythm of about 2 years is present in many industrial figures, and has also been reported in weather and other natural phenomena.[4] As yet, no one knows its cause, but this fact does not prevent use of this information.

Amplitude of the 2-Year Wave

From 1912 to World War II the average over-all amplitude of the 2-year wave was 7.6 percent. From 1940 through 1947 it was 0.6 percent. (For details of computation, see Table 5.) If, in future years, the 2-year tendency resumes with its old-time vigor-(For after a distortion, or artificial damping, these waves generally do) important differences in alternate years owing to this 2-year force can be expected.

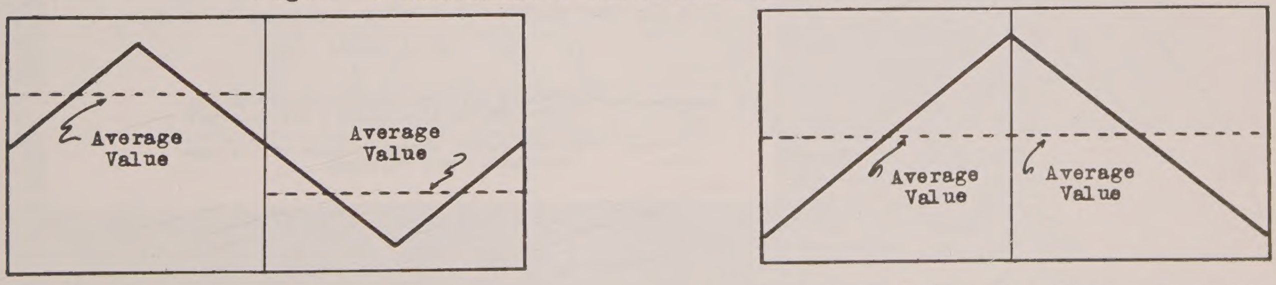
Length of the 2-Year Wave

From a study of the annual figures alone it is impossible to say whether or not the wave is exactly 2 years in length. A study of monthly figures of viscose rayon deliveries, 1923 to 1936 inclusive, however, indicates that the series has a rhythm of about 24 1/4 months.[5] It is possible that a similar study of monthly figures of viscose filament yarn production from 1911 to 1948 would show a rhythm of similar length.

If, in any series, the peaks of the 2-year rhythm come in the middle of even years, or vice versa, the wave will show up clearly in the annual figures. If, on the other hand, the crests and troughs come at year-end, the annual figures will show nothing, even though the wave is still fully operative. (See Figure 4.)

If the rhythm really is 24 1/4 months, it will thus gradually fade out of the annual averages, even though it remains in full force in the monthly figures. It will "slip" forward one month every four cycles (eight years), and move forward six months from a position of maximum effect on the annual figures to one of no effect at all on the annual figures in six times eight,

Figure 4. DIAGRAMMATIC REPRESENTATION OF A 2-YEAR WAVE



A. Annual Effect When Peaks Come at the Middle of a Year: Yearly Averages for First and Second Year Differ.

B. Annual Effect When Peaks Come at the End of a Year: Yearly Averages for First and Second Years Are the Same.

or forty-eight, years. For accurate forecasting, therefore, a study of the monthly figures is important.

Part III. The 3 1/2-Year Rhythm

The 3 1/2-year wave can be detected statistically in the original figures and even by a trained eye in Figure 2 (a chart of the "raw" production figures plotted on ratio ruling). But it will appear more clearly after the elimination of the effect of the 2-year wave. This has been done by increasing the production figures for every even year from 1911 to 1939 by 3.8 percent (half of 7.6 percent) and decreasing the production for every odd year during the period by the same amount. Similarly we increase even-numbered war and post-war years from 1940 to 1948 by 0.3 percent, and decrease odd-numbered years during this period by a like percentage. The result is recorded in Table 6 and plotted on ratio scale in Figure 5 by a solid line.

Emergence of 3 1/2-Year Wave

Starting with 1937 as a peak year and counting backwards, indicates highs relative to trend at 4-, 3-, 4-, 3-, 4-, 3-year intervals.

It will be easier to follow the technique outlined in Part II, however, and to compute a 3-year moving average trend of these corrected figures (Table 7), thus plotted as a broken line on Figure 5. The percentages which the values of the solid line bear to this moving average are shown in Table 8 and Figure 6. The 4-, 3-, 4-, 3-year tendency is clearly evident.

It seems probable that this average 3 1/2-year wave is the well-established 41-month rhythm so universal in American industry.[6] It has been found in more than half of some 500 price and production series that have been studied by various investigators.[2] This assumption of a 41-month length in this series should, be checked by a study of the monthly figures. Such a study would involve at least twice the work of the present investigation, however and is not within the scope of the present report.

Seven-Year Phase

A moment's reflection will show that if a perfectly regular 3 1/2-year wave exists it will be seven years before it will again come around to the same phase relationship with the calendar year. This fact is illustrated by Figure 7. Percentages up to World War II, therefore, were thrown into a seven-year periodic table (Table 9), which table represents the 3 1/2-year wave listed twice. An average (mean or median) of those values represents the average successive annual effect of the 3 1/2-year wave.

I see no evidence of the 3 1/2-year waves from 1940 to 1948, but arbitrarily assume that they are present

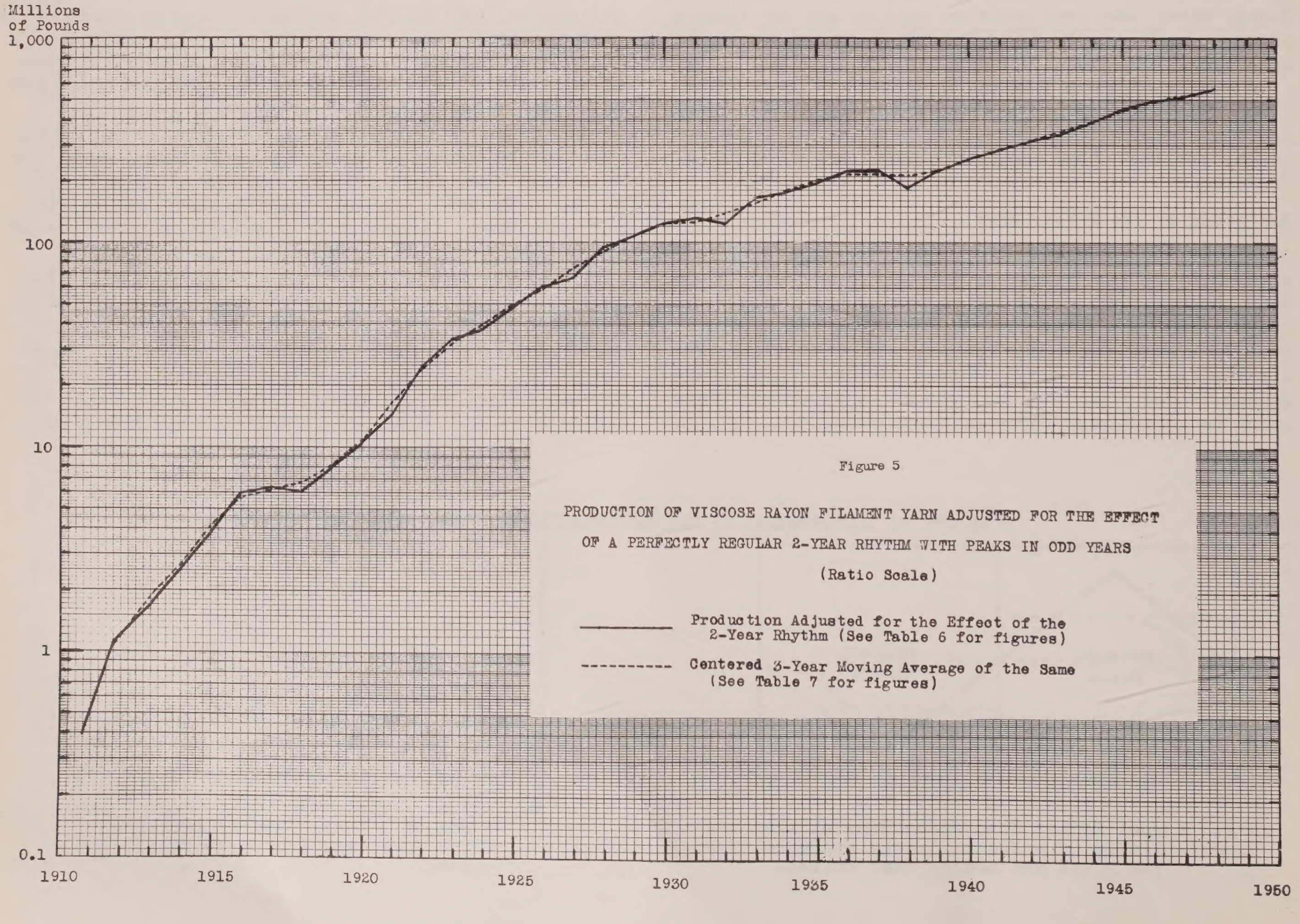


Figure 5

PRODUCTION OF VISCOSE RAYON FILAMENT YARN ADJUSTED FOR THE EFFECT OF A PERFECTLY REGULAR 2-YEAR RHYTHM WITH PEAKS IN ODD YEARS

(Ratio Scale)

at 1/10 of their average 1911-1937 amplitudes. In Part IV will appear the justification for this assumption.

Adjustment for Distortions

There are, however, two slight distortions in this picture. First, a small amount of a 3 1/2-year wave remains in a 3-year moving average. Hence, the deviations from a moving average of this length will not show the full effect of the wave. That is, the true amplitude of the 3 1/2-year wave is slightly greater than that shown in the percentages used. The figures can be adjusted for this distortion by increasing all amplitudes by 13 percent, as shown on Figure 6 by means of a broken line.

The second distortion comes from the fact that we are probably dealing here with a 41- instead of a 42-month (3 1/2-year) rhythm. If this is so, the crests will slip back a month every cycle, two months every seven years. Thus, a crest that came in December in 1911 would come two months earlier, or in October, in 1918, in August in 1925, in June of 1932 and April of 1939. The averages we have constructed will fit well enough for the middle portion of our data, but will be slightly in error toward the ends, and particularly will be out of timing on any projection.

This slippage is not too important in the broad picture, yet if the projections are to be used as a basis for action, the real answer is to do the entire study over, using monthly figures. I recommend that this be done by anyone who plans to spend any money on the basis of this work.

The combined effect of the 2-year rhythm and the 3 1/2-year rhythm from 1911 to 1948 is shown in Table 10 and Chart 8.

Part IV. The 6-Year Rhythm

A skilled eye, even though knowing where to look, could hardly pick out the 6-year rhythm in the raw figures of viscose rayon filament yarn production from 1911 to 1948 plotted in Figure 2. Nevertheless it can be seen in the 2-year moving averages plotted by a broken line (Figure 2).

By proceeding as before, the figures are adjusted for the 2-year wave (Figure 5) and for the 3 1/2-year wave shown in Figure 6. The adjusted figures are given in Table 11 and plotted in Figure 9. The 6-year wave is now easily observable (counting from low to low backward from 1938).

Following earlier procedures, I took a 2-year moving average of a 6-year moving average (Table 12) and plotted the results as a broken line in Figure 9. I then computed the percentages that the adjusted values are of the moving average (Table 13) and plotted their results in Figure 10.

Averaging successive 6-year sections obtains the values of the typical or average pre-war 6-year wave as shown in Table 14. It is shown to have an over-all amplitude of 24 percent. These values are fitted or idealized and plotted as a broken line in Figure 10. A wave for the war and post-war years is added (arbitrarily) at 1/6 the value of the regular 1911-1939 6-year wave. Justification for this assumption will also appear in the parts which follow.

The combined effect of the 2-year, the 3 1/2-year and the 6-year rhythms from 1911 to 1948 is shown in Table 15 and plotted on Figure 11.

Six-Year Rhythm Well Established

The 2-year rhythm and the 41-month rhythm are so well-known and have been described so fully in print by various authors* that I have not taken space to discuss them. The 6-year rhythm is even better established, but not so much has been printed about it.

It has been found to be present for as far back as there are figures in cotton prices (218 years), sunspots with alternate cycles reversed (198 years), automobile production (55 years), orders received by General Electric Company (55 years), and in dozens of other series of natural science and business figures, one of them extending over as long a period as 1,200 years (tree rings on the average in each 181 years).

---

* SEE REFERENCES 2, 3, 6, 7, 8, 9, 10.

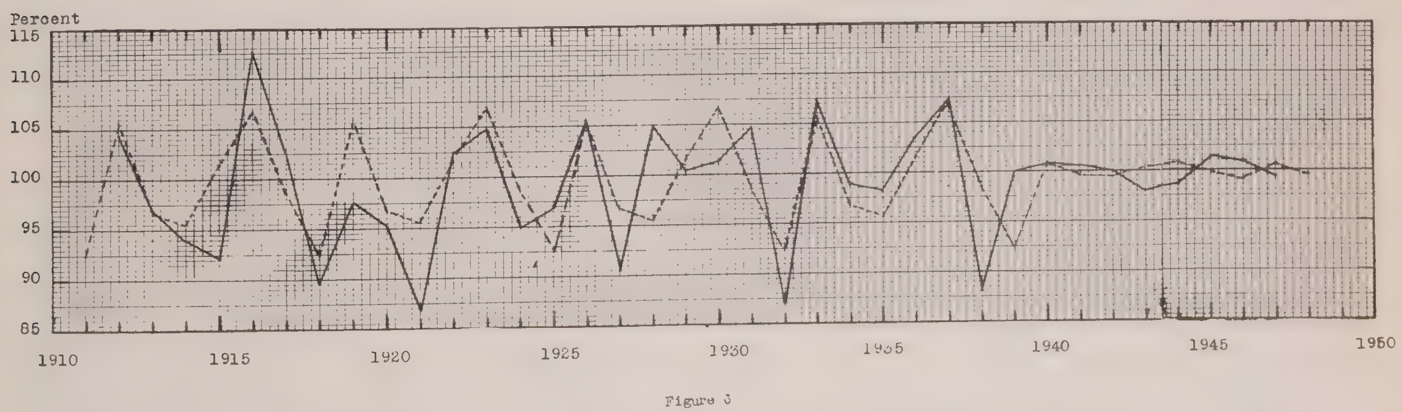


Figure 6

THE 3-1/2-YEAR RHYTHM IN THE PRODUCTION OF VISCOSE RAYON FILAMENT YARN

——— Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year Wave, Are of the Centered 3-Year Moving Average of the Same (See Table 8 for figures)

---------- Diagrammatic Representation of a Perfectly Regular Rhythm with Peaks at 3-, 4-, 3-, 4-Year Intervals (See Table 9 for figures)

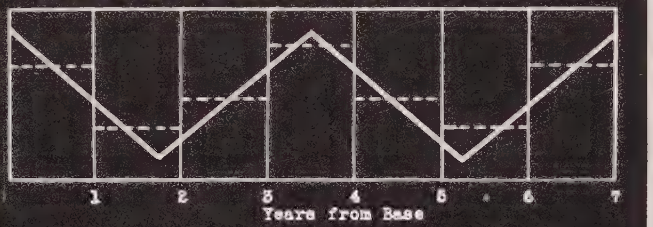
Part V. The 2 3/4-Year Rhythm

The data of Figure 9 have been adjusted for the idealized 6-year wave, as plotted with a broken line on Figure 10 and made symmetrical by using the 100 percent line as an axis. This is done by using values 12 percent above and 12 percent below trend instead of values 9 percent above and 15 percent below a line of constant value (Table 16). This procedure prevents distorting the level of the trend line. It results in the values that are plotted with a solid line in Figure 12.

The residual shows clearly (as a minor distortion of the smooth underlying growth trend) a fluctuation that is probably the well-known* 33-month, or 2 3/4-year, ("retail") rhythm, more precisely determined in some series to be 32.85 months in length. The peaks relative to them may be noted by counting backwards, 3, 3, 3, 2; 3, 3, 3, 3, 2; 3, 3, and 2 from 1945. Obviously, the existence and length of this fourth rhythm needs to be confirmed by a study of the monthly figures. Yet it may be identified in the annual data.

Figure 7

DIAGRAMMATIC REPRESENTATION OF TWO 3-1/2-YEAR WAVES



The diagram shows that it takes seven years for the wave to come around again to the place of beginning, relative to the calendar year.

To reveal it, I computed a 3-year moving average of the data shown in Figure 12 (Table 17 and Figure 12, broken line). Then I computed the percentages that these figures are of the moving averages (Table 18). These percentages are plotted in Figure 13, together with a perfectly regular 3-, 3-, 3-, 2-year pattern.

Amplitude of the 2 3/4-Year Wave

Assuming that 2 3/4 years is the correct length, I threw these percentages into a 2 3/4-year periodic table as shown in Table 19. The table gives (a) the pre-war and (b) the war and post-war values shown at the bottom of the table. In pre-war years, the over-all amplitude was 8.1 percent but in war and post-war years, 1.1 percent. The percentages so obtained, however, need to be reduced by 8 percent (to adjust for loss in the moving average, which is 9 percent longer than the wave).

Emergence of the Trend

After the values shown in Figure 12 have been ad-

---

* See Reference 2. 10.

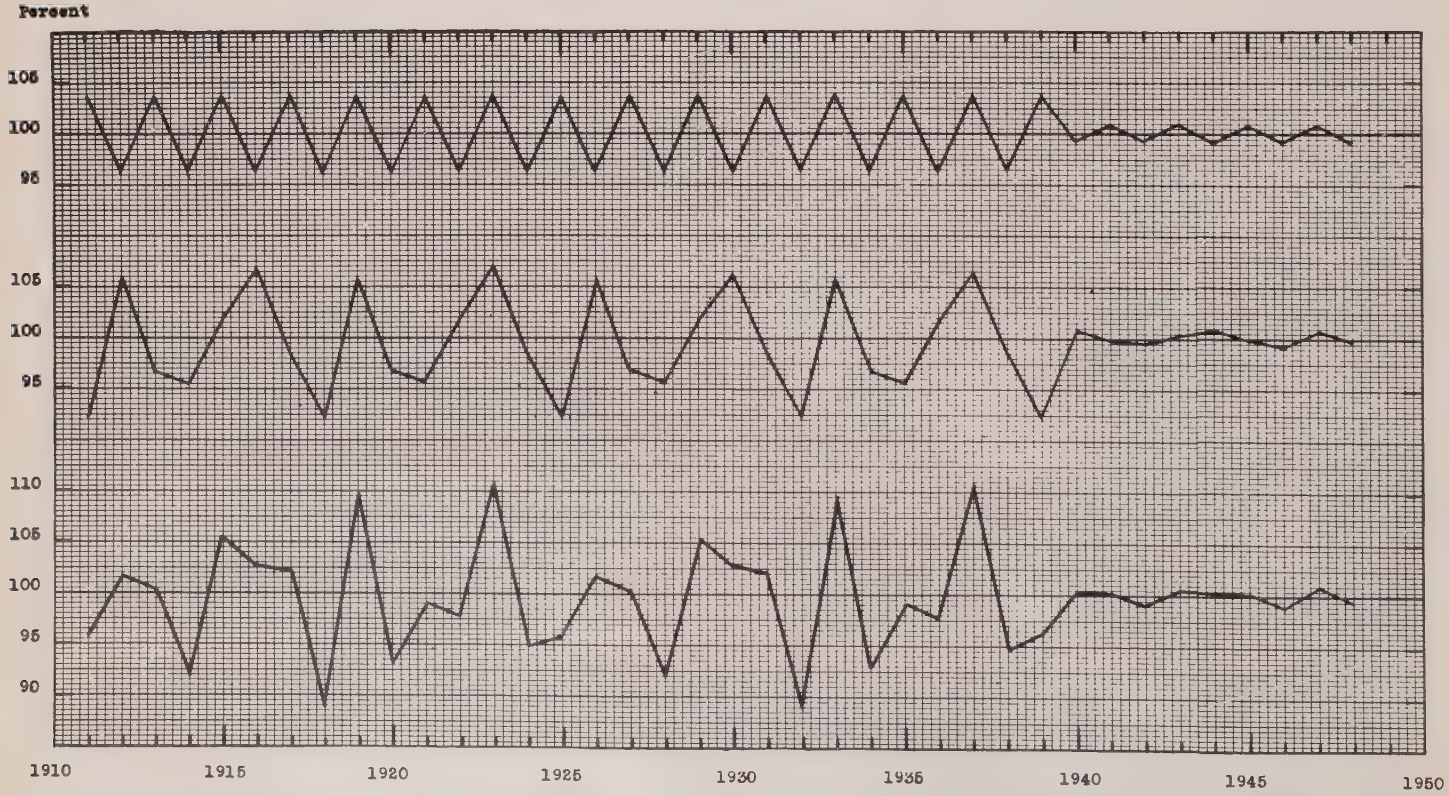


Chart 8

THE 2-YEAR RHYTHM AND THE 3-1/2-YEAR RHYTHM AND THEIR SYNTHESIS

(See Table 10 for figures)

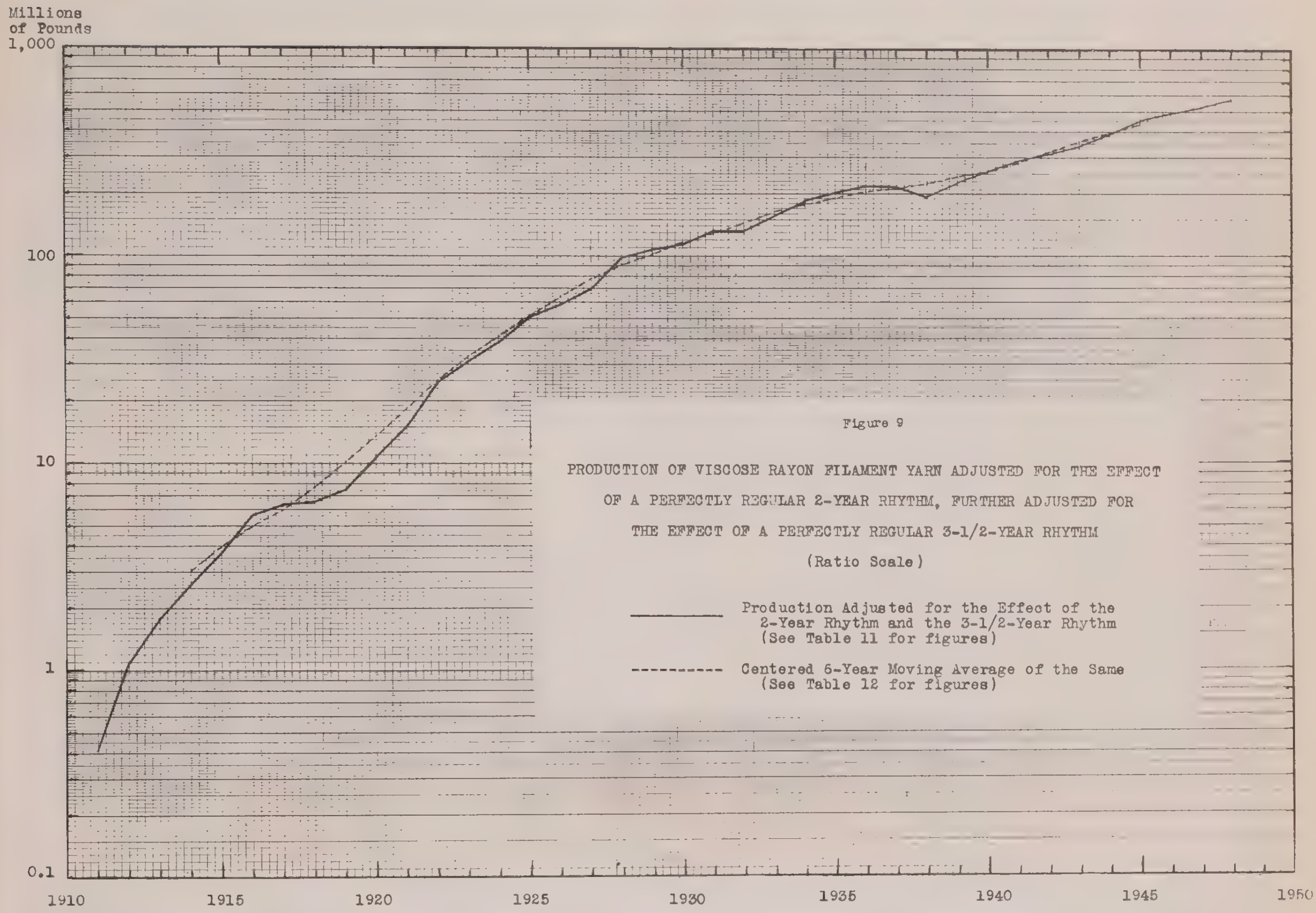


Figure 9

PRODUCTION OF VISCOSE RAYON FILAMENT YARN ADJUSTED FOR THE EFFECT OF A PERFECTLY REGULAR 2-YEAR RHYTHM, FURTHER ADJUSTED FOR THE EFFECT OF A PERFECTLY REGULAR 3-1/2-YEAR RHYTHM

(Ratio Scale)

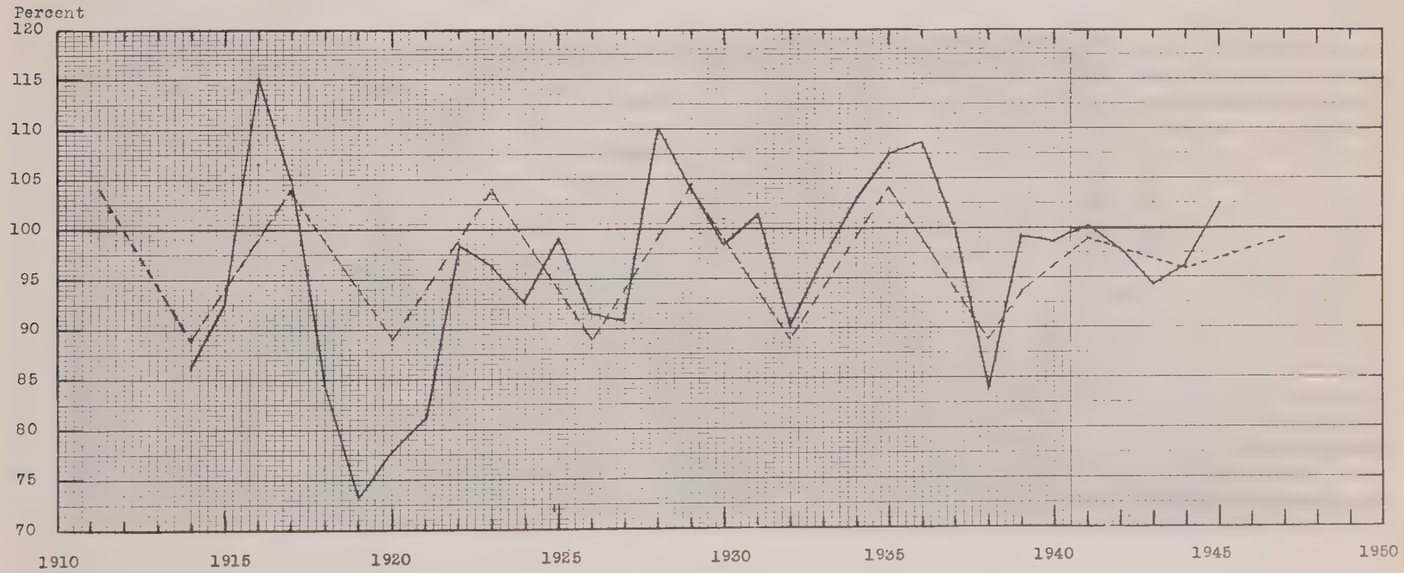


Figure 10

THE 6-YEAR RHYTHM IN THE PRODUCTION OF VISCOSE RAYON FILAMENT YARN

——— Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year and 3 1/2-Year Rhythms, Are of the Centered 6-Year Moving Average of the Same (See Table 13 for figures)

——— Diagrammatic Representation of a Perfectly Regular 6-Year Rhythm (See Table 14 for figures)

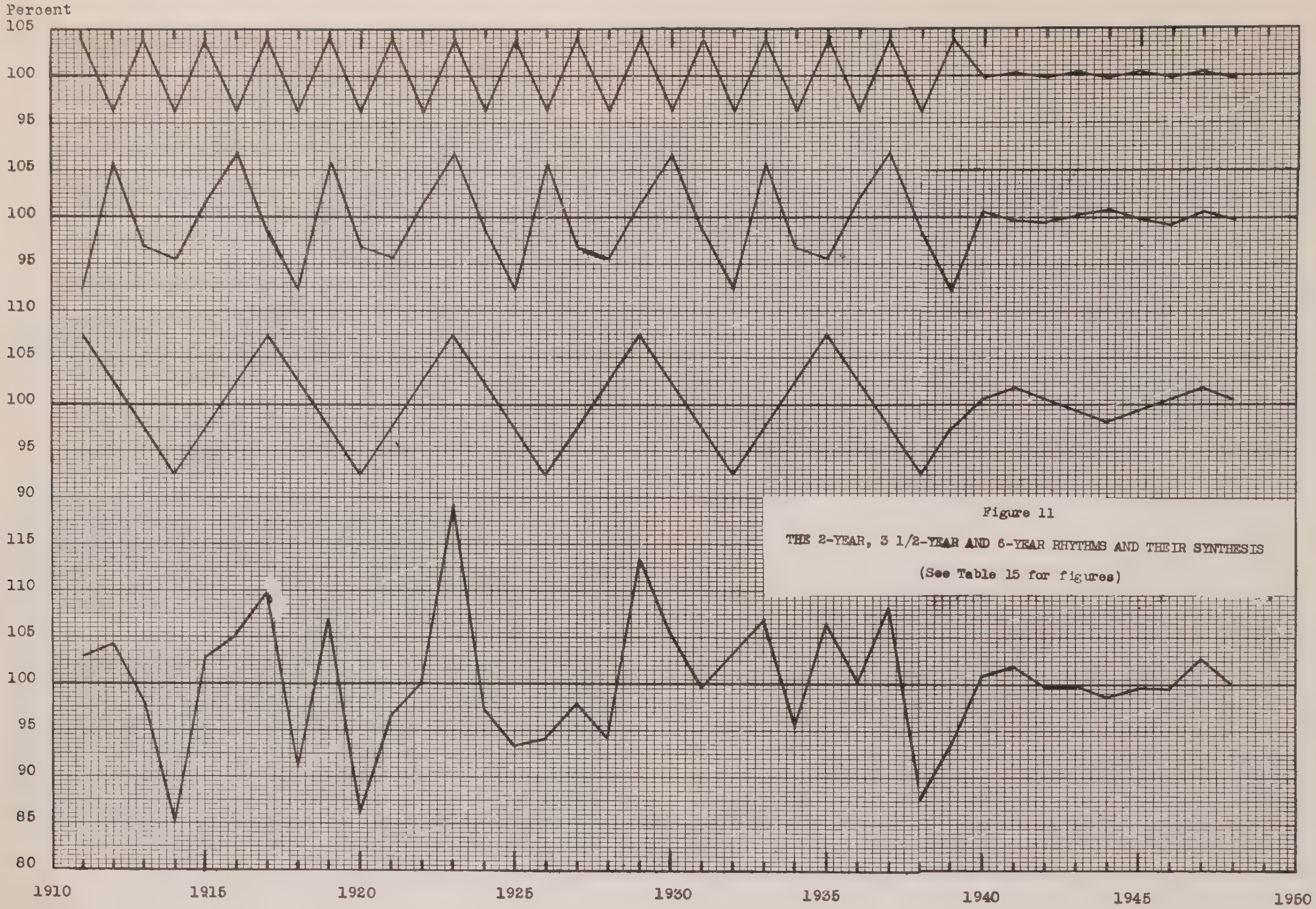


Figure 11

THE 2-YEAR, 3 1/2-YEAR AND 6-YEAR RHYTHMS AND THEIR SYNTHESIS

(See Table 15 for figures)

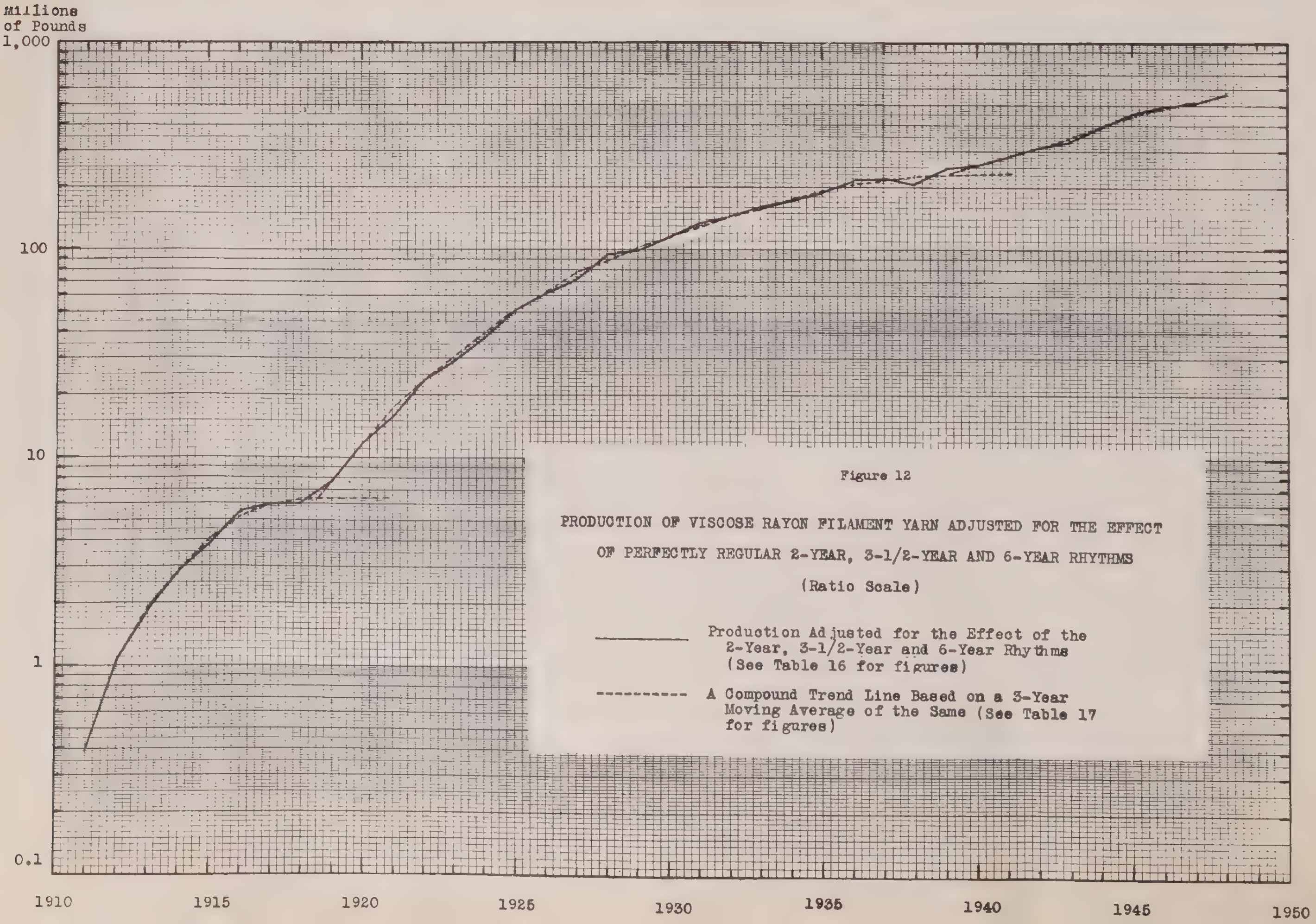


Figure 12

PRODUCTION OF VISCOSE RAYON FILAMENT YARN ADJUSTED FOR THE EFFECT OF PERFECTLY REGULAR 2-YEAR, 3-1/2-YEAR AND 6-YEAR RHYTHMS

(Ratio Scale)

———— Production Adjusted for the Effect of the 2-Year, 3-1/2-Year and 6-Year Rhythms (See Table 16 for figures)

------------ A Compound Trend Line Based on a 3-Year Moving Average of the Same (See Table 17 for figures) justed for the values indicated in Table 19, it gives an approximation of the underlying growth trend, together with all the accidental fluctuations that may be present in the series. Smoothing this series graphically to eliminate the accidental fluctuations gives the values recorded in Table 20 and plotted on Figure 14. After adjusting the data for perfectly regular 2-year, 3 1/2-year, 6-year, and 2 3/4-year waves of well-known length, we get as a result an almost perfectly smooth underlying growth trend line. This gives increased confidence in the wave determinations and in the validity of the results. In addition, it would seem to justify the assumption made in regard to war and post-war amplitudes.

Part VI. The Underlying Growth Trend

The underlying growth trend shows what appear to be three distinct periods, or stages. By 1918 all growth of the first stage appears to have ceased, but by 1919 a rebirth occurred that continued into 1939. By this latter year, growth again almost ceased In 1940 there is again evidence of a rebirth that has carried the curve upward through 1948.

Rate of Growth Decreasing

Underlying growth from 1939 to 1945 averaged about 12 percent, but, as nearly as I can estimate it with the use of annual figures, the underlying growth trend from 1945 to 1946 was about 10 percent; from 1946 to 1947, 8 percent; and from 1947 to 1948, 6 percent. The important thing is that the drastic falling-off in rate of growth since 1945 is a definite fact that must be taken into account by all who wish to forecast this series.

Part VII. Synthesis

The values of all the waves from 1911 to 1948 are shown in Table 21 and Figure 15. The table and figure also show the product (synthesis) of these four waves.

How to combine the four waves is obvious to a statistician, but may not be so readily understood by others, though it is relatively simple. In 1911, for example, the 2-year wave had a force of value of 103.8 percent; that is, it was "responsible" for production of 3.8 percent above trend. In the same year (1911) the other waves had the forces or values indicated as follows:

The 3 1/2-year wave had a value of 92.3 percent.
The 2 3/4-year wave had a value of 104.1 percent.
The 6-year wave had a value of 107.5 percent.

To get the combined effect of the waves, we must multiply 103.8 percent by 92.3 percent, and multiply the product by 104.1 percent, and multiply that product by 107.5 percent. The answer is 107.2 percent, which represents the combined effect of the four waves for the year 1911. In a similar manner, the synthesis has been made for each year. It is plotted as the fifth curve on Figure 15.

Synthesis of Waves with Trend

To synthesize the waves with the trend, I took each value of the underlying growth trend and multiplied it by the combined effect of the 2-, 2 3/4-, 3 1/2-, and 6-year waves as shown in Table 21 and plotted on Figure 15. This may be compared to the original curve with which we started as shown in Figure 16. This shows the extent to which the four perfectly regular and well-known cycles, and also what we have called the "underlying growth trend," collectively explain the growth and fluctuations of the viscose rayon filament yarn industry.

Part VIII. Projection

If the 2-year, 2 3/4-year, 3 1/2-year and 6-year rhythms remain as they seem to have been since 1940, their combined effect from 1949 to 1960 will approximate the figures given in Table 22, Part A, and plotted on Figure 17, Part A. If they resume 1911-1939 strength, however, the expected combined effect will be as shown in Table 22, Part B, and plotted on Figure

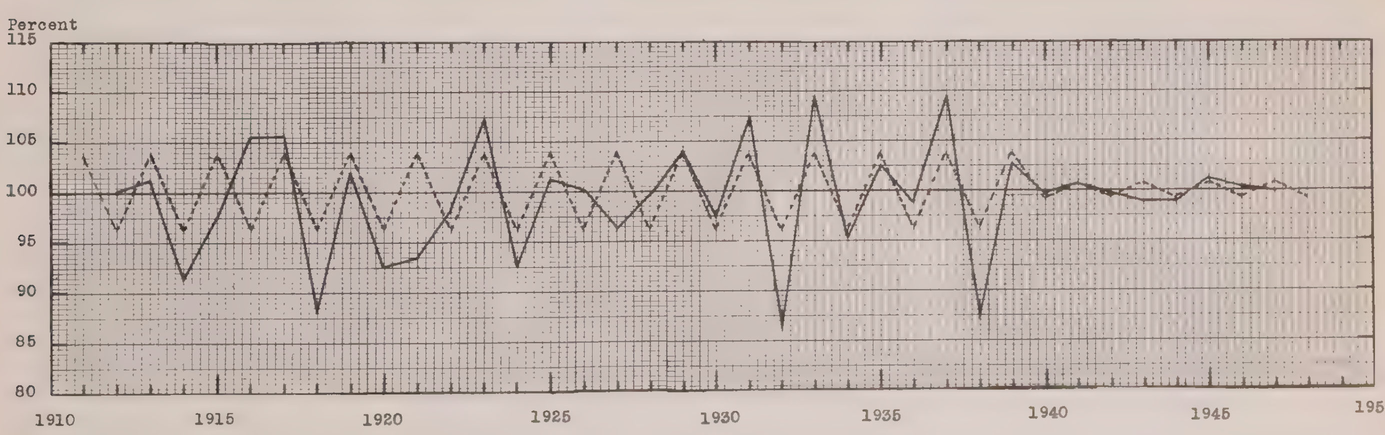


Figure 3

THE 2-YEAR RHYTHM IN THE PRODUCTION OF VISCOSE RAYON FILAMENT YARN

——— Percentages that the Production of Viscose Rayon Filament Yarn Are of the Centered 2-Year Moving Average of the Same (See Table 4 for figures)

------- Diagrammatic Representation of a Perfectly Regular 2-Year Rhythm (See Table 5 for figures)

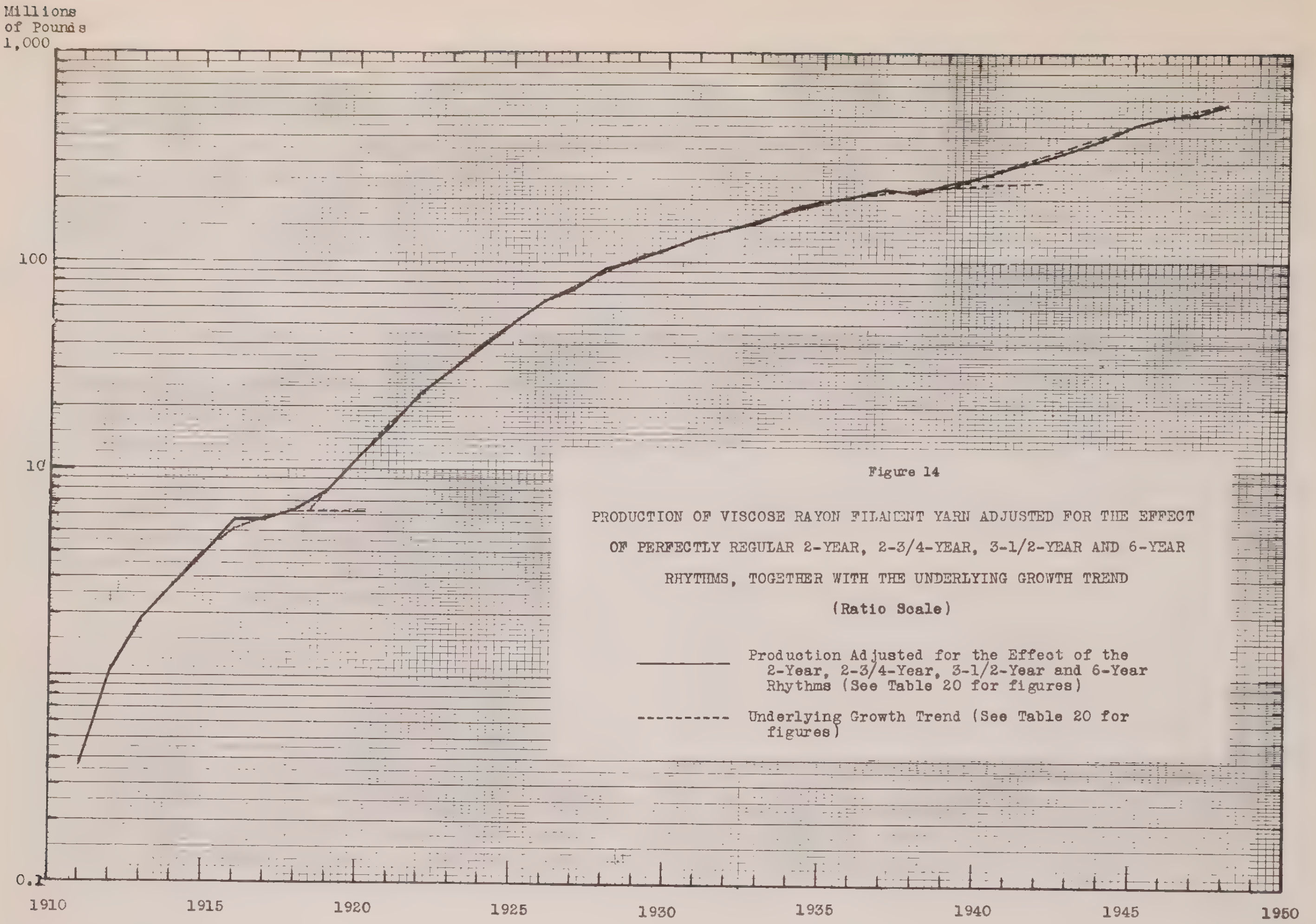


Figure 14

PRODUCTION OF VISCOSE RAYON FILAMENT YARN ADJUSTED FOR THE EFFECT OF PERFECTLY REGULAR 2-YEAR, 2-3/4-YEAR, 3-1/2-YEAR AND 6-YEAR RHYTHMS, TOGETHER WITH THE UNDERLYING GROWTH TREND

(Ratio Scale)

——— Production Adjusted for the Effect of the 2-Year, 2-3/4-Year, 3-1/2-Year and 6-Year Rhythms (See Table 20 for figures)

---------- Underlying Growth Trend (See Table 20 for figures)

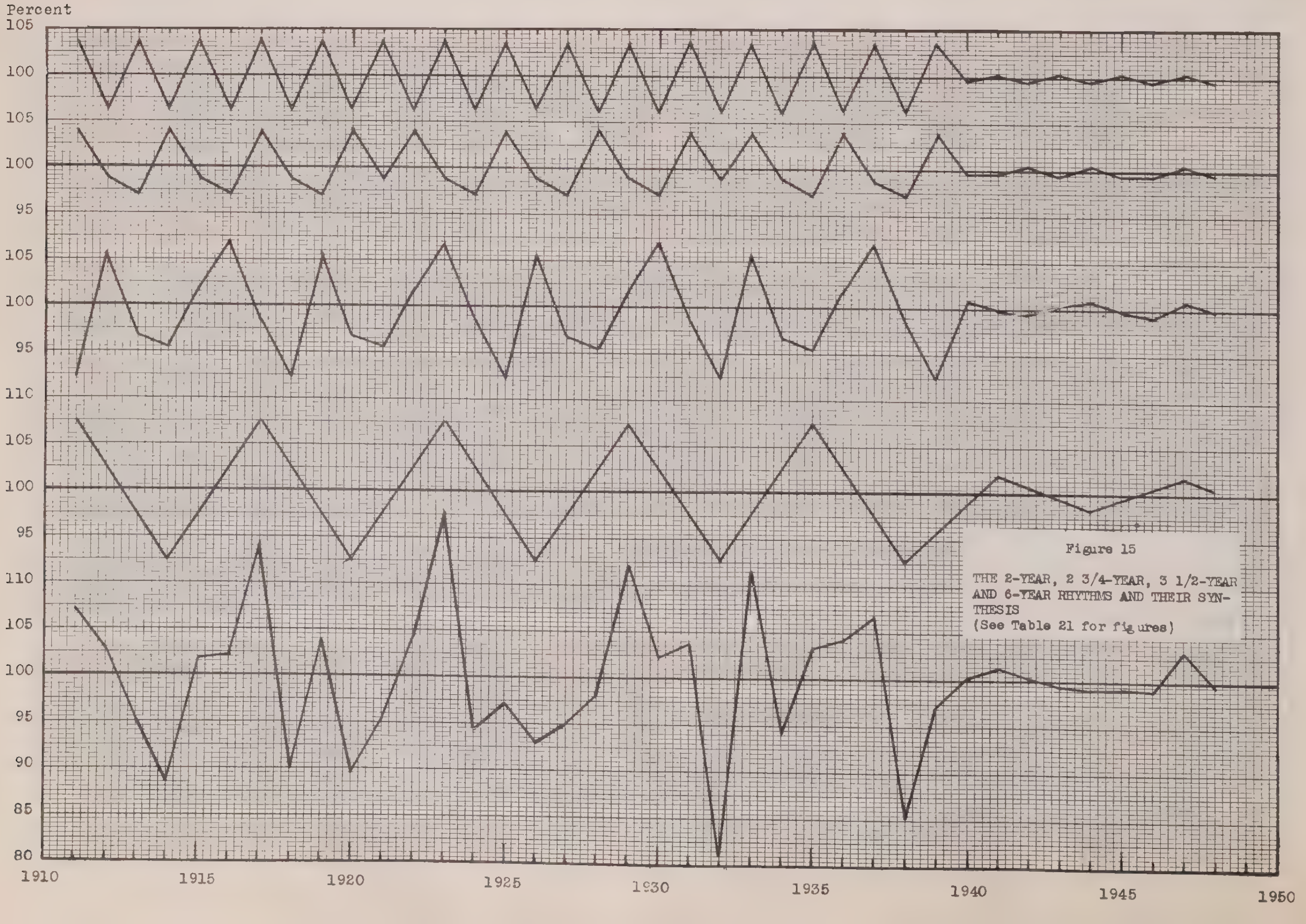


Figure 15

THE 2-YEAR, 2 3/4-YEAR, 3 1/2-YEAR AND 6-YEAR RHYTHMS AND THEIR SYNTHESIS
(See Table 21 for figures)

17, Part B. It is a simple matter of arithmetic to extend either of these syntheses as far into the future as one wishes.

Both of these projections are based on 2-year, 2 3/4-year, and 3 1/2-year lengths instead of the more probable 24 1/4-month, 32.85-month and 41-month lengths. It is not possible, however, to try to be more exact with annual data. Roughly speaking, then, we can expect the underlying growth trend to be influenced as shown in Figure 17 if the rhythms (a) continue at war and post-war strength, or (b) resume at pre-war strength.

Course of the Trend

No one knows what the underlying growth trend will be, but one way to use the above information is to make it throw light, year by year as time unfolds, on what the underlying growth trend is really doing. (It would be much better to use the results of a study of monthly figures to learn each month or each quarter how the underlying situation is changing.) To get figures for the underlying growth trend, we may divide the actual production data for future years when available, by the appropriate figures for the composite effect of the rhythms. On the assumption that the rhythms are continuing, the quotient will be an approximation of the underlying growth trend, subject to any distortions of accidental origin, as well as to the fact that annual data will not give the exact length of the rhythms as well as monthly data.

It is worth repeating at this point that the underlying growth trend, after showing average growth of 12 percent from 1939 to 1945, seems to have slackened to 10 percent from 1945 to 1946, 8 percent from 1946 to 1947, and 6 percent from 1947 to 1948. This very important fact, in addition to all other facts at the disposal of the forecaster, should be taken into account by anyone who has the task of estimating the future production of viscose rayon filament yarn.

Part IX. Recommended Procedures

Anyone who wishes to use this information in a practical way should take the following steps:*

1. Obtain monthly figures, 1911 to date.
2. Determine **exact length, shape, and phase** of the so-called 2-year rhythm (24 1/4 months?) both (a) pre-war and (b) war and post-war.

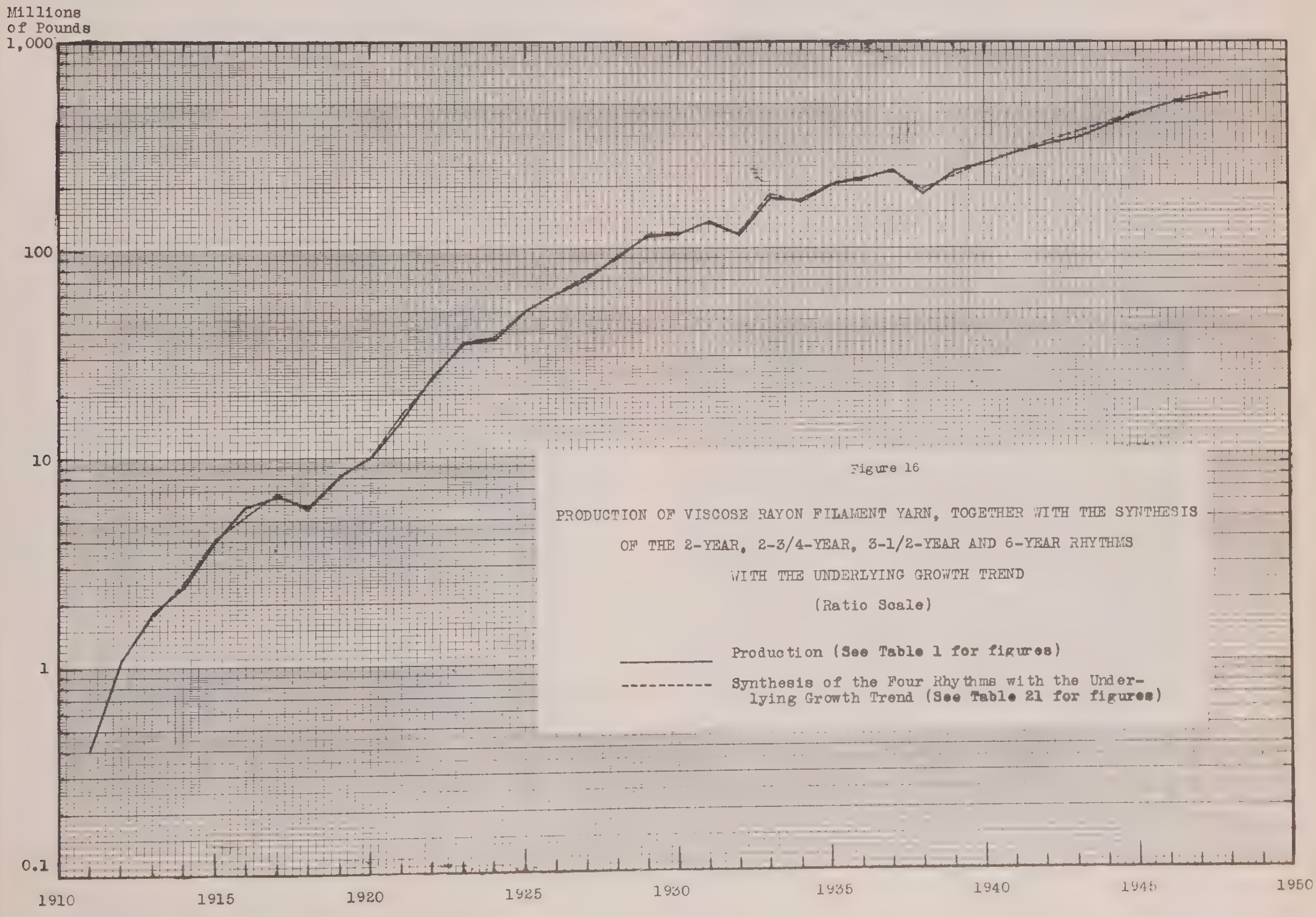


Figure 16

PRODUCTION OF VISCOSE RAYON FILAMENT YARN, TOGETHER WITH THE SYNTHESIS OF THE 2-YEAR, 2-3/4-YEAR, 3-1/2-YEAR AND 6-YEAR RHYTHMS WITH THE UNDERLYING GROWTH TREND

(Ratio Scale)

---

* ALL OF THESE MAY SOUND LIKE A LOT OF WORK, BUT FOREKNOWLEDGE OF FUTURE PROBABILITIES IS NOT AN EASY TASK. OBVIOUSLY, A PROCEDURE THAT WILL THROW LIGHT ON FUTURE EVENTS IS WELL WORTH THE EFFORT.

3. Do the same for what in this paper has been called the 2 3/4-year rhythm (32.85 months?).

4. Do the same for the so-called 3 1/2-year rhythm (41 months?).

5. Do the same for the so-called 6-year rhythm (70.9 months, or 73.3 months, or a combination of the two?).

6. In all of these determinations it will be helpful to work with the percentages that the actual data are of the tentative underlying growth trend, as reported here, converted to a monthly basis.

7. Adjust for all these rhythms.

8. Revise the underlying growth trend to take account of the more accurate wave length, wave shape, and timing determinations.

9. Revise estimates of the recent behavior of the underlying growth trend, and project it into the future taking all known factors into account.

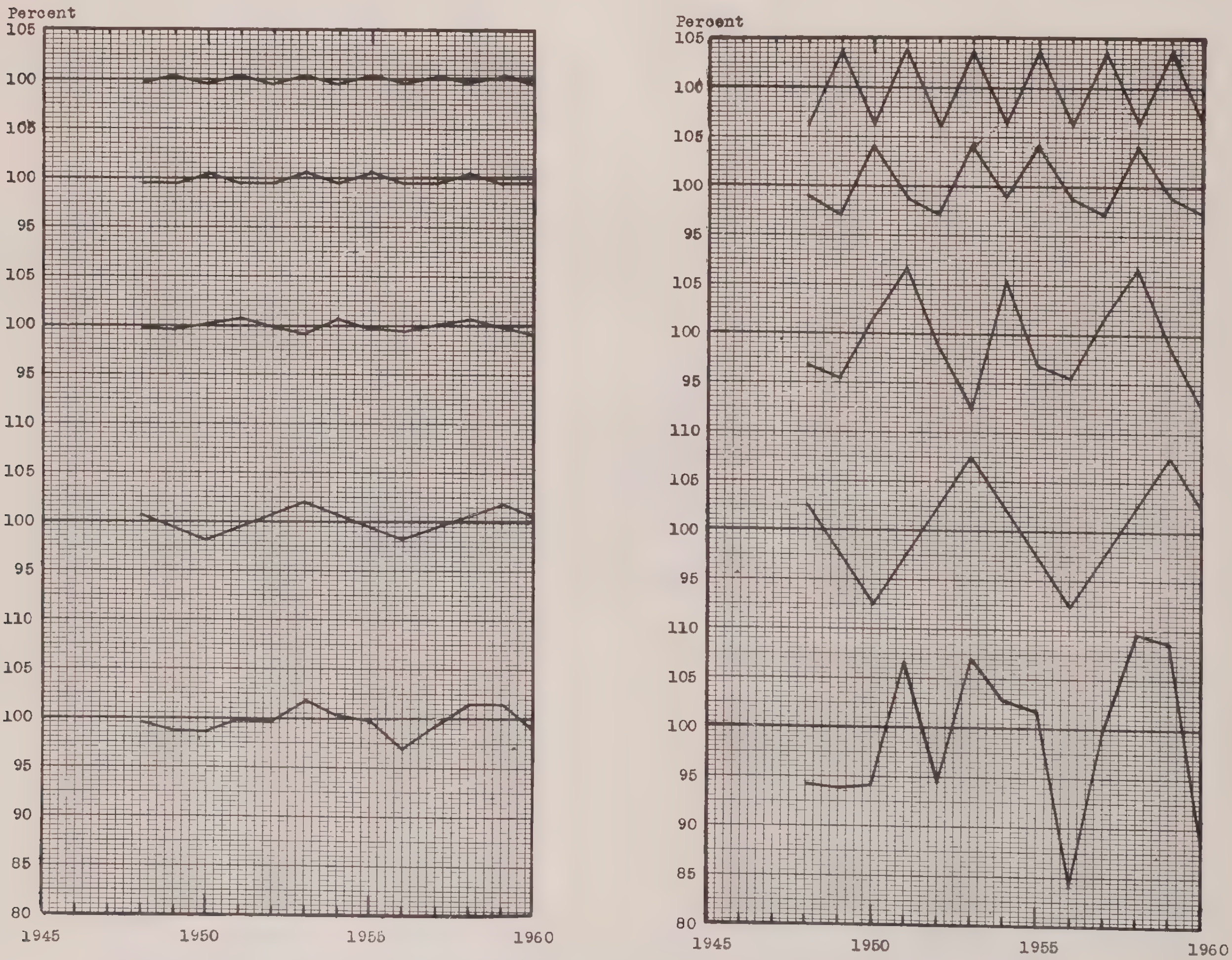
10. In view of the increased importance of rayon tire cord, it would be well to make a study of the rhythms and trend in tire production. I do not know what they are, but I do know that the 6-year rhythm is very important in the factory sales of passenger cars.

11. A study should also be made of the rhythms and trend in the **sales** of viscose rayon filament yarn.

12. Project the combined **monthly** waves into the future on both (a) the war and post-war and (b) the pre-war basis, and "wrap them around" the projected growth trend.

13. Each quarter investigate to see the extent to which the pre-war waves have come back, and to see any changes creeping into the underlying growth situation.

14. Revise the forecasts periodically in the light of all these factors.



A. Projection Based on 1940-1948 Amplitudes

B. Projection Based on 1911-1939 Amplitudes

Figure 17

THE 2-YEAR, 2-3/4-YEAR, 3-1/2-YEAR AND 6-YEAR RHYTHMS
AND THEIR SYNTHESIS PROJECTED TO 1960
(See Table 22 for figures)

REFERENCES

1. **The Rayon Organon**, February 1949.

2. Dewey, E. R., and F. F. Dakin, **Cycles--The Science of Prediction**. Henry Holt & Co., New York, 1947.

3. Croxton, F. E., and D. J. Cowden, **Applied General Statistics**. Prentice Hall, Inc., New York, 1941.

4. Whitney, Paul C., "The Prediction of Tides," **United States Naval Institute Proceedings**, Vol. 66, No. 12, Whole Number 454. December, 1940.

5. Dewey, E. R., "The 24 1/2-Month Rhythm in Non-Acetate Rayon Deliveries, 1923-1936." Unpublished manuscript in the files of the Foundation for the Study of Cycles

6. Armstrong, C. E., "The Short Term Business Cycles," **The Review of Economic Statistics**, May, 1936.

7. Kitchin, Joseph, "Cycles and Trends in Economic Factors," **The Review of Economic Statistics**, January, 1923.

8. Crum, W. L., "Cycles of rates on Commercial Paper," **The Review of Economic Statistics**, January, 1923.

9. Schumpeter, Joseph A., **Business Cycles**, McGraw-Hill Book Company, Inc., New York, 1939.

10. Warren, G. F., and F. A. Pearson, **World Prices and the Building Industry**. John Wiley and Sons, Inc., New York, 1937.

11. Dewey, E. R., "The 6-Year Cycle," **Cycles--A Monthly Report** Vol. 1, No. 5, December, 1950. "The 6-Year Cycle," **Cycles--A Monthly Report** Vol. 4, No. 1, January 1953, "Cycles in Wholesale Prices: Cotton (a) War and Post-War Behavior, (b) The 6-Year Rhythm, 1731-32 to 1947-48," **Report No. 2** of Foundation for the Study of Cycles, 1949; "Cycles in Tree Ring Widths: Lukuchukai District, Arizona, Hint of a 6-Year Rhythm," **Report No. 7** of the Foundation for the Study of Cycles, 1949.

TABLES

Table 1

Production of Viscose* Rayon Filament Yarn in the United States, 1911-1948**
(See Chart 1, and Chart 2, solid line)

Year	Production (Millions of Pounds)	Year	Production (Millions of Pounds)
1911	0.4	1931	135.2
1912	1.1	1932	116.4
1913	1.8	1933	172.4
1914	2.4	1934	170.3
1915	3.9	1935	202.0
1916	5.8	1936	214.9
1917	6.5	1937	238.2
1918	5.8	1938	181.5
1919	8.2	1939	231.3
1920	10.0	1940	257.1
1921	14.9	1941	287.5
1922	24.0	1942	310.5
1923	34.8	1943	338.5
1924	36.2	1944	383.5
1925	49.4	1945	448.8
1926	60.1	1946	491.2
1927	70.4	1947	525.2
1928	91.2	1948	562.3
1929	113.0		
1930	117.5		

* Wherever the word "viscose" appears in this report it is understood to include nitrocellulose process rayon yarn until its production was discontinued in 1934, and also to include the production of cuprammonium filament yarn from its first production to date.

** Source: Rayon Organon. February, 1949, page 20.

Table 2

The Percentage that Each Year's Production of Viscose Rayon Filament Yarn Is of Production for the Previous Year

Year	Percent
1911	----
1912	275.0
1913	163.6
1914	133.3
1915	162.5
1916	148.7
1917	112.1
1918	89.2
1919	141.4
1920	122.0
1921	149.0
1922	161.1
1923	145.0
1924	104.0
1925	136.5
1926	121.7
1927	117.1
1928	129.5
1929	123.9
1930	104.0
1931	115.1
1932	86.1
1933	148.1
1934	98.8
1935	118.6
1936	106.4
1937	110.8
1938	76.2
1939	127.4
1940	111.2
1941	111.8
1942	108.0
1943	109.0
1944	113.3
1945	117.0
1946	109.4
1947	106.9
1948	107.1

Centered 2-Year Moving Average of the Production of Viscose Rayon Filament Yarn
(See Chart 2, broken line)

Year	Moving Average	Year	Moving Average
		1931	126.08
1912	1.10	1932	135.10
1913	1.78	1933	157.88
1914	2.63	1934	178.75
1915	4.00	1935	197.30
1916	5.50	1936	217.50
1917	6.15	1937	218.20
1918	6.58	1938	208.13
1919	8.05	1939	225.30
1920	10.78	1940	258.25
1921	15.95	1941	285.65
1922	24.43	1942	311.75
1923	32.45	1943	342.75
1924	39.15	1944	388.58
1925	48.78	1945	443.08
1926	60.00	1946	489.10
1927	73.02	1947	525.98
1928	91.45		
1929	108.68		
1930	120.80		

For the benefit of those who are not statisticians, but who may wish to know, this is how a centered, or 2-year, moving average of a 2-year moving average is computed: Average the first and second figures of the original data. Average the second and third figures, then average the third and fourth, the fourth and fifth, and so forth, through the entire series. This gives the first 2-year moving average. Then, using these averages as data, do it all over again. This provides a 2-year moving average of a 2-year moving average. The second series of calculations is made because it is not possible to center exactly a moving average with an even number of terms. Plot the first figure of the results in the 1912 position, and so on to 1947. There will be one figure missing at each end. That is why the broken line in Figure 2 runs only from 1912 to 1947, inclusive, and cannot continue to 1948 until the figures for 1949 are available to average in with the 1948 figures to extend the moving average to 1948.

Table 4

Percentages that the Production of Viscose Rayon Filament Yarn Are of the Centered 2-Year Moving Average of the Same
(See Chart 3, solid line)

Year	Percent
1911	---
1912	100.0
1913	101.1
1914	91.3
1915	97.5
1916	105.5
1917	105.7
1918	88.1
1919	101.9
1920	92.8
1921	93.4
1922	98.2
1923	107.2
1924	92.5
1925	101.3
1926	100.2
1927	96.4
1928	99.7
1929	104.0
1930	97.3
1931	107.2
1932	86.2
1933	109.2
1934	95.3
1935	102.4
1936	98.8
1937	109.2
1938	87.2
1939	102.7
1940	99.6
1941	100.6
1942	99.6
1943	98.8
1944	98.7
1945	101.3
1946	100.4
1947	99.9
1948	---

Table 5

Two-Year Periodic Table of the Percentages that the Production of Viscose Rayon Filament Yarn Are of the Centered 2-Year Moving Average of the Same
(See Chart 3, broken line)

Part A. The Years 1912 through 1939

Base Year	Years after Base Year 1	2
1911	100.0	101.1
1913	91.3	97.5
1915	105.5	105.7
1917	88.1	101.9
1919	92.8	93.4
1921	98.2	107.2
1923	92.5	101.3
1925	100.2	96.4
1927	99.7	104.0
1929	97.3	107.2
1931	86.2	109.2
1933	95.3	102.4
1935	98.8	109.2
1937	87.2	102.7
Sum	1333.1	1439.2
Average	95.2	102.8

Over-all Amplitude Equals 7.6

Part B. The Years 1940 through 1947

Base Year	Years after Base Year 1	2
1939	99.6	100.6
1941	99.6	98.8
1943	98.7	101.3
1945	100.4	99.9
Sum	398.3	400.6
Average	99.6	100.2

Over-all Amplitude Equals 0.6

Table 6

Production of Viscose Rayon Filament Yarn Adjusted for the Effect of a Perfectly Regular 2-Year Rhythm with Peaks in Odd Years
(See Chart 5, solid line)

Over-all amplitude, 1911-1939, equals 7.6 per cent.
Over-all amplitude, 1940-1948, equals 0.6 per cent.

Year	(A) Production (Millions of Pounds	(B) The 2-Year Rhythm (Based on Table 5)	(C) Production Adjusted for 2-Year Rhythm (Millions of Pounds) (A ÷ B)
1911	0.4	103.8 %	0.39
1912	1.1	96.2	1.14
1913	1.8	103.8	1.73
1914	2.4	96.2	2.50
1915	3.9	103.8	3.76
1916	5.8	96.2	6.03
1917	6.5	103.8	6.26
1918	5.8	96.2	6.0
1919	8.2	103.8	7.9
1920	10.0	96.2	10.4
1921	14.9	103.8	14.4
1922	24.0	96.2	24.9
1923	34.8	103.8	33.5
1924	36.2	96.2	37.6
1925	49.4	103.8	47.6
1926	60.1	96.2	62.5
1927	70.4	103.8	67.8
1928	91.2	96.2	94.8
1929	113.0	103.8	108.9
1930	117.5	96.2	122.1
1931	135.2	103.8	130.3
1932	116.4	96.2	121.0
1933	172.4	103.8	166.1
1934	170.3	96.2	177.0
1935	202.0	103.8	194.6
1936	214.9	96.2	223.4
1937	238.2	103.8	229.5
1938	181.5	96.2	188.7
1939	231.3	103.8	222.8
1940	257.1	99.7	257.9
1941	287.5	100.3	286.6
1942	310.5	99.7	311.4
1943	338.5	100.3	337.5
1944	383.5	99.7	384.7
1945	448.8	100.3	447.5
1946	491.2	99.7	492.7
1947	525.2	100.3	523.6
1948	562.3	99.7	564.0

Column B is 100 per cent plus-or-minus 1/2 the over-all amplitude derived in Table 5.

Table 7

Centered 3-Year Moving Average of the Production of Viscose Rayon Filament Yarn Adjusted for the Effect

Year	Production Adjusted for 2-Year Rhythm (from Table 6, Col. C)	3-Year Moving Average of Adjusted Production
1911	0.39	---
1912	1.14	1.09
1913	1.73	1.79
1914	2.50	2.66
1915	3.76	4.10
1916	6.03	5.35
1917	6.26	6.10
1918	6.0	6.7
1919	7.9	8.1
1920	10.4	10.9
1921	14.4	16.6
1922	24.9	24.3
1923	33.5	32.0
1924	37.6	39.6
1925	47.6	49.2
1926	62.5	59.3
1927	67.8	75.0
1928	94.8	90.5
1929	108.9	108.6
1930	122.1	120.4
1931	130.3	124.5
1932	121.0	139.1
1933	166.1	154.7
1934	177.0	179.2
1935	194.6	198.3
1936	223.4	215.8
1937	229.5	213.9
1938	188.7	213.7
1939	222.8	223.1
1940	257.9	255.8
1941	286.6	285.3
1942	311.4	311.8
1943	337.5	344.5
1944	384.7	389.9
1945	447.5	441.6
1946	492.7	487.9
1947	523.6	526.8
1948	564.0	---

(Continued in next column)

Table 7 (Continued)

Table 8

Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year Wave, Are of the Centered 3-Year Moving Average of the Same
(See Chart 6, solid line)

Year	Percent
1911	*
1912	104.5
1913	96.7
1914	94.0
1915	91.7
1916	112.7
1917	102.6
1918	89.6
1919	97.5
1920	95.4
1921	86.7
1922	102.5
1923	104.7
1924	94.9
1925	96.7
1926	105.4
1927	90.4
1928	104.8
1929	100.3
1930	101.4
1931	104.7
1932	87.0
1933	107.4
1934	98.8
1935	98.1
1936	103.5
1937	107.3
1938	88.3
1939	99.9
1940	100.8
1941	100.5
1942	99.9
1943	98.0
1944	98.7
1945	101.3
1946	101.0
1947	99.4
1948	*

* As the moving average runs only from 1912 to 1947, there are no percentages for 1911 and 1948.

Table 9

Seven-Year Periodic Table of the Percentages of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year Wave, Are of the Centered 3-Year Moving Average of the Same (See Chart 6, broken line)

Part A. The Years 1912 through 1939

Base Year	Years After Base Year						
	1	2	3	4	5	6	7
1911	104.5	96.7	94.0	91.7	112.7	102.6	89.6
1918	97.5	95.4	86.7	102.5	104.7	94.9	96.7
1925	105.4	90.4	104.8	100.3	101.4	104.7	87.0
1932	107.4	98.8	98.1	103.5	107.3	88.3	99.9
Sum	414.8	381.3	383.6	398.0	426.1	390.5	373.2
Average (Mean)	103.7	95.3	95.9	99.5	106.5	97.6	93.3
Median	105.0	97.1	96.0	101.4	106.0	98.7	93.2
Adjustment**	105.7	96.7	95.5	101.6	106.8	98.5	92.3

Part B. The Years 1940 through 1947

Base Year	Years After Base Year						
	1	2	3	4	5	6	7
1939	100.8	100.5	99.9	98.0	98.7	101.3	101.0
1946	99.4						
Average (Mean)	100.1	100.5	99.9	98.0	98.7	101.3	101.0
Adjustment***	100.6	99.7	99.5	100.2	100.7	99.9	99.2

* Deviations from 100% are increased 13% because some of a 3 1/2-year cycle remains in a 3-year moving average. A 3 1/2-year cycle in the deviations from such a moving average is thus smaller than it is in the actual figures. The wave as it appears in the deviations must therefore be given greater amplitude before it is used as a correction factor.

** The 3 1/2-year wave from 1940 through 1947 is assumed to be present at 1/10 of the average 1911-1937 amplitude. See text, bottom of page 6.

Addendum: After this report was finished it was discovered that the median in the second column above should have been recorded as 96.1 instead of 97.1. Consequently the adjusted value should have been 95.6 instead of 96.7. This error introduces a slight distortion in the remaining work, but in view of the very much larger distortion already in the work due to the use of annual instead of monthly figures, it does not seem necessary to recompute the remaining tables.

Table 10

Synthesis of the 2-Year Rhythm and the 3 1/2-Year Rhythm of the Given Amplitudes (See Chart 9)

Year	(A) 2-Year Wave	(B) 3-1/2-Year Wave	(C) Synthesis (A x B)
1911	103.8	92.3	95.8
1912	96.2	105.7	101.7
1913	103.8	96.7	100.4
1914	96.2	95.5	91.9
1915	103.8	101.6	105.5
1916	96.2	106.8	102.7
1917	103.8	98.5	102.2
1918	96.2	92.3	88.8
1919	103.8	105.7	109.7
1920	96.2	96.7	93.0
1921	103.8	95.5	99.1
1922	96.2	101.6	97.7
1923	103.8	106.8	110.9
1924	96.2	98.5	94.8
1925	103.8	92.3	95.8
1926	96.2	105.7	101.7
1927	103.8	96.7	100.4
1928	96.2	95.5	91.9
1929	103.8	101.6	105.5
1930	96.2	106.8	102.7
1931	103.8	98.5	102.2
1932	96.2	92.3	88.8
1933	103.8	105.7	109.7
1934	96.2	96.7	93.0
1935	103.8	95.5	99.1
1936	96.2	101.6	97.7
1937	103.8	106.8	110.9
1938	96.2	98.5	94.8
1939	103.8	92.3	95.8
1940	99.7	100.6	100.3
1941	100.3	99.7	100.0
1942	99.7	99.5	99.2
1943	100.3	100.2	100.5
1944	99.7	100.7	100.4
1945	100.3	99.9	100.2
1946	99.7	99.2	98.9
1947	100.3	100.6	100.9
1948	99.7	99.7	99.4

Table 11

Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of a Regular 2-Year Rhythm, Further Adjusted for the Effect of a Regular 3 1/2-Year Rhythm

Year	(A) Production Adjusted for 2-Year Rhythm (Millions of Pounds)	(B) The 3-1/2-Year Rhythm	(C) Production Adjusted for both 2-Year and 3-1/2-Year Rhythms (Millions of Pounds) (A ÷ B)
1911	0.39	92.3	0.42
1912	1.14	105.7	1.08
1913	1.73	96.7	1.79
1914	2.50	95.5	2.62
1915	3.76	101.6	3.70
1916	6.03	106.8	5.65
1917	6.26	98.5	6.36
1918	6.0	92.3	6.5
1919	7.9	105.7	7.5
1920	10.4	96.7	10.8
1921	14.4	95.5	15.1
1922	24.9	101.6	24.5
1923	33.5	106.8	31.4
1924	37.6	98.5	38.2
1925	47.6	92.3	51.6
1926	62.5	105.7	59.1
1927	67.8	96.7	70.1
1928	94.8	95.5	99.3
1929	108.9	101.6	107.2
1930	122.1	106.8	114.3
1931	130.3	98.5	132.3
1932	121.0	92.3	131.1
1933	166.1	105.7	157.1
1934	177.0	96.7	183.0
1935	194.6	95.5	203.8
1936	223.4	101.6	219.9
1937	229.5	106.8	214.9
1938	188.7	98.5	191.6
1939	222.8	92.3	241.4
1940	257.9	100.6	256.4
1941	286.6	99.7	287.5
1942	311.4	99.5	313.0
1943	337.5	100.2	336.8
1944	384.7	100.7	382.0
1945	447.5	99.9	447.9
1946	492.7	99.2	496.7
1947	523.6	100.6	520.5
1948	564.0	99.7	565.7

Column B is derived from Table 9.

Table 12

Centered, or 2-Year, Moving Average of a 6-Year Moving Average of the Production of Viscose Rayon Filament Yarn Adjusted for the Effect of the 2- and 3 1/2-year rhythms

Year	(A) Production Adjusted for both 2-Year and 3-1/2-Year Rhythms (Millions of Pounds) (from Table 11)	(B) Centered, or 2-Year, Moving Average of a 6-Year Moving Average of Column (A)
1911	0.42	---
1912	1.08	---
1913	1.79	---
1914	2.62	3.04
1915	3.70	3.99
1916	5.65	4.91
1917	6.36	6.07
1918	6.5	7.70
1919	7.5	10.23
1920	10.8	13.88
1921	15.1	18.6
1922	24.5	24.9
1923	31.4	32.6
1924	38.2	41.2
1925	51.6	52.1
1926	59.1	64.6
1927	70.1	77.3
1928	99.3	90.3
1929	107.2	103.1
1930	114.3	116.3
1931	132.3	130.5
1932	131.1	145.6
1933	157.1	162.4
1934	183.0	178.1
1935	203.8	190.0
1936	219.9	202.1
1937	214.9	215.2
1938	191.6	228.3
1939	241.4	243.0
1940	256.4	261.0
1941	287.5	287.0
1942	313.0	320.1
1943	336.8	357.3
1944	382.0	396.7
1945	447.9	437.2
1946	496.7	---
1947	520.5	---
1948	565.7	---

See footnote to Table 3 for method of calculating a centered moving average based on an even number of terms.

Table 13

Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year and 3-1/2-Year Rhythms, Are of the Centered 6-Year Moving Average of the Same (See Chart 10, solid line)

Year	Percent
1911	---
1912	---
1913	---
1914	86.2
1915	92.7
1916	115.1
1917	104.8
1918	84.4
1919	73.3
1920	77.8
1921	81.2
1922	98.4
1923	96.3
1924	92.7
1925	99.0

(Continued on next page)

Table 13 (Continued)

1926	91.5
1927	90.7
1928	110.0
1929	104.0
1930	98.3
1931	101.4
1932	90.0
1933	96.7
1934	102.8
1935	107.3
1936	108.8
1937	99.9
1938	83.9
1939	99.3
1940	98.2
1941	100.2
1942	97.8
1943	94.3
1944	96.3
1945	102.4
1946	---
1947	---
1948	---

Table 14

Six-Year Periodic Table of the Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year and 3 1/2-Year Waves, Are of the Centered 6-Year Moving Average of the Same

(See Chart 10, broken line)

Base Year	Years After Base Year 1	2	3	4	5	6
1913	86.2	92.7	115.1	104.8	84.4	73.3
1919	77.8	81.2	98.4	96.3	92.7	99.0
1925	91.5	90.7	110.0	104.0	98.3	101.4
1931	90.0	96.7	102.8	107.3	108.8	99.9
1937	83.9	99.3	98.2	100.2	97.7	94.3
1941	96.4	103.0				
Median*	88.1	94.7	102.8	104.0	97.5	99.0
Idealization** 1911-1939 to base 1913	92.5	97.5	102.5	107.5	102.5	97.5
Idealization*** 1940-1948 to base 1937	98.2	99.4	100.6	101.8	100.6	99.4

* The average of the two middle value figures in columns 1 and 2; of the two middle values in columns 3, 4, 5, and 6.

** The median raised to be symmetrical around the 100 per cent axis, in shape as well as position.

*** The 6-year wave from 1940 through 1948 is, in this line, assumed to be present at 1/6 of the average 1911-1937 amplitude. See text, page 8.

Table 15

Synthesis of the 2-Year 3-1/2-Year and 6-Year Rhythms of the Given Amplitudes

(See Chart 11)

Year	(A) Synthesis of 2-Year and 3-1/2-Year Waves (from Table 10)	(B) 6-Year Wave	(C) Composite of All 3 Waves (A x B)
1911	95.8	107.5	103.0
1912	101.7	102.5	104.2
1913	100.4	97.5	97.9
1914	91.9	92.5	85.0
1915	105.5	97.5	102.9
1916	102.7	102.5	105.3
1917	102.2	107.5	109.9
1918	88.8	102.5	91.0
1919	109.7	97.5	107.0
1920	93.0	92.5	86.0
1921	99.1	97.5	96.6
1922	97.7	102.5	100.1
1923	110.9	107.5	119.2
1924	94.8	102.5	97.2
1925	95.8	97.5	93.4
1926	101.7	92.5	94.1
1927	100.4	97.5	97.9
1928	91.9	102.5	94.2
1929	105.5	107.5	113.4
1930	102.7	102.5	105.3
1931	102.2	97.5	99.6
1932	88.8	92.5	82.1
1933	109.7	97.5	107.0
1934	93.0	102.5	95.3
1935	99.1	107.5	106.5
1936	97.7	102.5	100.1
1937	110.9	97.5	108.1
1938	94.8	92.5	87.7
1939	95.8	97.5	93.4
1940	100.3	100.6	100.9
1941	100.0	101.8	101.8
1942	99.2	100.6	99.8
1943	100.5	99.4	99.9
1944	100.4	98.2	98.6
1945	100.2	99.4	99.6
1946	98.9	100.6	99.5
1947	100.9	101.8	102.7
1948	99.4	100.6	100.0

Column B based on Table 14.

Table 16

Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of Perfectly Regular 2-Year, 3-1/2-Year and 6-Year Rhythms

(See Chart 12, solid line)

Year	(A) Production Adjusted for both 2-Year and 3-1/2-Year Rhythms (Millions of Pounds) (from Table 11)	(B) The 6-Year Rhythm	(C) Production Adjusted for the 2-Year, 3-1/2-Year and 6-Year Rhythms (Millions of Pounds) (A ÷ B)
1911	0.42	107.5	0.39
1912	1.08	102.5	1.05
1913	1.79	97.5	1.84
1914	2.62	92.5	2.83
1915	3.70	97.5	3.79
1916	5.65	102.5	5.51
1917	6.36	107.5	5.92
1918	6.5	102.5	6.3
1919	7.5	97.5	7.7
1920	10.8	92.5	11.7
1921	15.1	97.5	15.5
1922	24.5	102.5	23.9
1923	31.4	107.5	29.2
1924	38.2	102.5	37.3
1925	51.6	97.5	52.9
1926	59.1	92.5	63.9
1927	70.1	97.5	71.9
1928	99.3	102.5	96.9
1929	107.2	107.5	99.7
1930	114.3	102.5	111.5
1931	132.3	97.5	135.7
1932	131.1	92.5	141.7
1933	157.1	97.5	161.1
1934	183.0	102.5	178.5
1935	203.8	107.5	189.6
1936	219.9	102.5	214.5
1937	214.9	97.5	220.4
1938	191.6	92.5	207.1
1939	241.4	97.5	247.6
1940	256.4	100.6	254.9
1941	287.5	101.8	282.4
1942	313.0	100.6	311.1
1943	336.8	99.4	338.8
1944	382.0	98.2	389.0
1945	447.9	99.4	450.6
1946	496.7	100.6	493.7
1947	520.5	101.8	511.3
1948	565.7	100.6	562.3

Column B based on Table 14.

Table 17

Three-Year Moving Average of the Production of Viscose Rayon Filament Yarn Adjusted for the Effect of the 2-Year, 3 1/2-Year and 6-Year Waves
(See Chart 12, broken line)

Year	(A) Production Adjusted for the 2-Year, 3-1/2-Year and 6-Year Rhythms (Millions of Pounds) (From Table 16)	(B) 3-Year Moving Average of Column (A)
1911	0.39	---
1912	1.05	1.09
1913	1.84	1.91
1914	2.83	2.82
1915	3.79	4.04
1916	5.51	5.07
1917	5.92	5.91
1918	6.3	6.36*
1919	7.7	7.7 *
1920	11.7	11.6
1921	15.5	17.0
1922	23.9	22.9
1923	29.2	30.1
1924	37.3	39.8
1925	52.9	51.4
1926	63.9	62.9
1927	71.9	77.6
1928	96.9	89.5
1929	99.7	102.7
1930	111.5	115.6
1931	135.7	129.6
1932	141.7	146.2
1933	161.1	160.4
1934	178.5	176.4
1935	189.6	194.2
1936	214.5	208.2
1937	220.4	214.0
1938	207.1	225.0
1939	247.6	230.0*
1940	254.9	254.2*
1941	282.4	282.8
1942	311.1	310.8
1943	338.8	346.3
1944	389.0	392.8
1945	450.6	444.4
1946	493.7	485.2
1947	511.3	522.4
1948	562.3	---

*Values for 1918, 1919, 1939 and 1940 determined graphically rather than by computing the 3-year moving average in order to express the behavior of the underlying growth trend as discussed in the text, page 10.

Table 18

Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year, 3 1/2-Year and 6-Year Rhythms, Are of the 3-Year Moving Average of the Same
(See Chart 13, solid line)

Year	Percent
1911	---
1912	96.3
1913	96.3
1914	100.4
1915	93.8
1916	108.7
1917	100.2
1918	99.1
1919	100.0
1920	100.9
1921	91.2
1922	104.4
1923	97.0
1924	93.7
1925	102.9

(Continued in next column)

Table 18 (Continued)

Year	Percent
1926	101.6
1927	92.7
1928	108.3
1929	97.1
1930	96.4
1931	104.7
1932	96.9
1933	100.4
1934	101.2
1935	97.6
1936	103.0
1937	103.0
1938	92.0
1939	107.7
1940	97.4
1941	99.9
1942	100.1
1943	97.8
1944	99.0
1945	101.4
1946	101.8
1947	97.9
1948	---

Table 19

Two-and-Three-Quarter-Year Periodic Table of the Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year, 3 1/2-Year and 6-Year Waves, Are of the 3-Year Moving Average of the Same
(See Chart 13, broken line)

Base Year	Years After Base Year 1	2	3
1911	96.3	96.3	100.4
1914	93.8	108.7	100.2
1917	99.1	100.0	100.9
1920	91.2	(91.2)*	104.4
1922	97.0	93.7	102.9
1925	101.6	92.7	108.3
1928	97.1	96.4	104.7
1931	96.9	(96.9)*	100.4
1933	101.2	97.6	103.0
1936	103.0	92.0	107.7
Average Median**	97.5	95.8	102.8
Adjusted values***, 1911-1939 to base 1911	98.8	97.1	104.1
Values****, 1940-1948 to base 1939	99.5	99.5	100.5

* Figures in parentheses are repeated from the previous year.

** The average of the four middle values in each column.

*** The median has been raised to be symmetrical around the 100 per cent axis. In addition, positive values should be increased by 8 per cent and negative values should be decreased by 8 per cent of their difference from 100 per cent. Eight per cent is the correction factor used when computing the amplitude of a 2 3/4-year wave in the deviations from a 3-year moving average.

**** The 2 3/4-year wave from 1940 through 1948 is assumed to be present at 1/7 of the average 1911-1939 amplitude. See text page 9.

Table 20

Production of Viscose Rayon Filament Yarn Adjusted for the Effect of Perfectly Regular 2-Year, 2-3/4-Year, 3-1/2-Year and 6-Year Rhythms, Together with the Underlying Growth Trend
(See Chart 14)

Year	(A) Production Adjusted for the 2-Year, 3-1/2-Year and 6-Year Rhythms (Millions of Pounds)(From Table 16)	(B) The 2-3/4-Year Rhythm	(C) Production Adjusted for the 2-Year, 3-1/2-Year, 6-Year and 2-3/4-Year Rhythms (Millions of Pounds)	(D) Underlying Growth Trend (Values in Column C Smoothed Graphically) (Millions of Pounds)
1911	0.39	104.1	0.37	0.37
1912	1.05	98.8	1.06	1.06
1913	1.84	97.1	1.89	1.85
1914	2.83	104.1	2.72	2.78
1915	3.79	98.8	3.84	4.00
1916	5.51	97.1	5.67	5.15
1917	5.92	104.1	5.69	5.85
1918	6.3	98.8	6.4	6.3
1919	7.7	97.1	7.9	7.8
1920	11.7	104.1	11.2	11.2
1921	15.5	98.8	15.7	16.5
1922	23.9	104.1	23.0	22.5
1923	29.2	98.8	29.6	30.0
1924	37.3	97.1	38.4	39.5
1925	52.9	104.1	50.8	51.0
1926	63.9	98.8	64.7	64.0
1927	71.9	97.1	74.0	76.0
1928	96.9	104.1	93.1	90.0
1929	99.7	98.8	100.9	102.5
1930	111.5	97.1	114.8	115.0
1931	135.7	104.1	130.4	130.0
1932	141.7	98.8	143.4	146.0
1933	161.1	104.1	154.8	160.4
1934	178.5	98.8	180.7	178.0
1935	189.6	97.1	195.3	194.2

(Continued on next page)

Table 20 (Continued)

Year	(A) Production Adjusted for the 2-Year, 3-1/2-Year and 6-Year Rhythms (Millions of Pounds) (From Table 16)	(B) The 2-3/4-Year Rhythm	(C) Production Adjusted for the 2-Year, 3-1/2-Year, 6-Year and 2-3/4-Year Rhythms (Millions of Pounds)	(D) Underlying Growth Trend (Values in Column C Smoothed Graphically) (Millions of Pounds)
1936	214.5	104.1	206.1	208.2
1937	220.4	98.8	223.1	218.0
1938	207.1	97.1	213.3	225.0
1939	247.6	104.1	237.8	230.0
1940	254.9	99.5	256.2	257.3
1941	282.4	99.5	283.8	287.8
1942	311.1	100.5	309.6	321.9
1943	338.8	99.5	340.5	359.9
1944	389.0	100.5	387.1	402.5
1945	450.6	99.5	452.9	450.2
1946	493.7	99.5	496.2	494.5
1947	511.3	100.5	508.8	533.3
1948	562.3	99.5	565.1	564.5

Column B based on Table 19.

Table 22

The 2-Year, 2-3/4-Year, 3-1/2-Year and 6-Year Rhythms and their Synthesis Projected to 1960 on (A) War and Post-War Amplitudes and (B) Pre-War Amplitudes

(See Chart 17)

Part A. War and Post-War Amplitudes

Year	2-Year Rhythm	3-1/2-Year Rhythm	6-Year Rhythm	2-3/4-Year Rhythm	Synthesis
1949	100.3	99.5	99.4	99.5	98.7
1950	99.7	100.2	98.2	100.5	98.6
1951	100.3	100.7	99.4	99.5	99.9
1952	99.7	99.9	100.6	99.5	99.7
1953	100.3	99.2	101.8	100.5	101.8
1954	99.7	100.6	100.6	99.5	100.4
1955	100.3	99.7	99.4	100.5	99.9
1956	99.7	99.5	98.2	99.5	96.9
1957	100.3	100.2	99.4	99.5	99.4
1958	99.7	100.7	100.6	100.5	101.5
1959	100.3	99.9	101.8	99.5	101.5
1960	99.7	99.2	100.6	99.5	99.0

Part B. Pre-War Amplitudes

Year	2-Year Rhythm	3-1/2-Year Rhythm	6-Year Rhythm	2-3/4-Year Rhythm	Synthesis
1949	103.8	95.5	97.5	97.1	93.8
1950	96.2	101.6	92.5	104.1	94.1
1951	103.8	106.8	97.5	98.8	106.8
1952	96.2	98.5	102.5	97.1	94.4
1953	103.8	92.3	107.5	104.1	107.2
1954	96.2	105.7	102.5	98.8	102.9
1955	103.8	* 96.7	97.5	104.1	* 101.9
1956	96.2	95.5	92.5	98.8	84.0
1957	103.8	101.6	97.5	97.1	99.9
1958	96.2	106.8	102.5	104.1	109.6
1959	103.8	98.5	107.5	98.8	108.6
1960	96.2	92.3	102.5	97.1	88.4

* See foot-note to Table 9.

Table 21

Composite Effect of the 2-Year, 2-3/4-Year, 3-1/2-Year and 6-Year Rhythms, and the Synthesis of these Waves with the Underlying Growth Trend

(See Chart 15, and Chart 16, broken line)

Year	(A) Synthesis of 2-Year, 3-1/2-Year and 6-Year Waves (from Table 15)	(B) 2-3/4-Year Wave	(C) Composite of All Four Waves	(D) Underlying Growth Trend (from Table 20)	(E) Synthesis of All Four Waves with the Trend (C x D)
1911	103.0	104.1	107.2	0.37	0.40
1912	104.2	98.8	102.9	1.06	1.09
1913	97.9	97.1	95.1	1.85	1.76
1914	85.0	104.1	88.5	2.78	2.46
1915	102.9	98.8	101.7	4.00	4.07
1916	105.3	97.1	102.2	5.15	5.26
1917	109.9	104.1	114.4	5.85	6.69
1918	91.0	98.8	89.9	6.3	5.66
1919	107.0	97.1	103.9	7.8	8.1
1920	86.0	104.1	89.5	11.2	10.0
1921	96.6	98.8	95.4	16.5	15.7
1922	100.1	104.1	104.2	22.5	23.4
1923	119.2	98.8	117.8	30.0	35.3
1924	97.2	97.1	94.4	39.5	37.3
1925	93.4	104.1	97.2	51.0	49.6
1926	94.1	98.8	93.0	64.0	59.5
1927	97.9	97.1	95.1	76.0	72.3
1928	94.2	104.1	98.1	90.0	88.3
1929	113.4	98.8	112.0	102.5	114.8
1930	105.3	97.1	102.2	115.0	117.5
1931	99.6	104.1	103.7	130.0	134.8
1932	82.1	98.8	81.1	146.0	118.4
1933	107.0	104.1	111.4	160.4	178.7
1934	95.3	98.8	94.2	178.0	167.7
1935	106.5	97.1	103.4	194.2	200.8
1936	100.1	104.1	104.2	208.2	216.9
1937	108.1	98.8	106.8	218.0	232.8
1938	87.7	97.1	85.2	225.0	191.7
1939	93.4	104.1	97.2	230.0	223.6
1940	100.9	99.5	100.4	257.3	258.3
1941	101.8	99.5	101.3	287.8	291.5
1942	99.8	100.5	100.3	321.9	322.9
1943	99.9	99.5	99.4	359.9	357.7
1944	98.6	100.5	99.1	402.5	398.9
1945	99.6	99.5	99.1	450.2	446.1
1946	99.5	99.5	99.0	494.5	489.6
1947	102.7	100.5	103.2	533.3	550.4
1948	100.0	99.5	99.5	564.5	561.7

Column B based on Table 19.

How it Came Out

A FORECAST OF VISCOSE RAYON FILAMENT YARN PRODUCTION

EARLY in 1949 I made a study of the cycles in viscose rayon filament yarn production. This report was published at the time as Foundation Report No. 1. It originally sold at $100.00 a copy. Because that report shows you just how a cycle analysis is made, complete with all the arithmetic, it is being reprinted in full as a supplement on pages 7—24 of this report.

Report No. 1 announced the discovery of four cycles in the production of viscose rayon filament yarn, viz., cycles 2 years, 2 3/4 years, 3 1/2 years, and 6 years in length. It synthesized (combined) these cycles and projected the synthesis into the future. How has the forecast worked out?

By way of explanation it should be said that in viscose rayon filament yarn production, as in so many phenomena, World War II greatly diminished the amplitude of the cycles. In rayon yarn production the diminished amplitude continued into 1946, 1947, and 1948. I did not feel myself sufficiently acquainted with the industry to know whether conditions were ripe for a return to pre-war amplitude, or whether the war and immediate post-war conditions would continue a short while longer. I therefore made two projections. In each projection I used the same four cycles, but in one projection I used the pre-war strength of each cycle, in the other I used the war and immediate post-war strength.

Apparently the cycles reasserted themselves at pre-war strength just about the time the report was written. The forecast shown below is therefore the one on this basis.

The forecast was in terms of percentage variation from trend. One can never be quite sure of what the underlying growth trend of a series of figures is. However, with the help of a French curve I made the best projection I could of the trend as it had showed itself in 1948 and prior thereto to obtain the following values:

1948	564.5	million pounds
1949	582.5	" "
1950	596.5	" "
1951	606.5	" "
1952	612.5	" "

You will notice that the differences between the values for the consecutive years are 18, 14, 10, and 6 million pounds respectively, and that these differences are each 4 million pounds less than the difference before.

The synthesis of the four cycles calls for the following percentages of trend:

1948	99.5%
1949	93.8%
1950	94.1%
1951	106.8%
1952	94.4%

Applying these percentages to the trend as given above we get the following values in millions of pounds:

1948 564.5 x 99.5% = 561.7
1949 582.5 x 93.8% = 546.4
1950 596.5 x 94.1% = 561.3
1951 606.5 x 106.8% = 647.7
1952 612.5 x 94.4% = 578.2

The actual production for these years was as follows:

1948	562.3	million pounds
1949	544.3	" "
1950	627.3	" "
1951	658.1	" "
*1952	575.9	" "

(*PRODUCTION FOR 1952 IS AN ESTIMATE BASED UPON DATA FOR THE FIRST THREE QUARTERS. FIGURES FOR THE FOURTH QUARTER ARE NOT AVAILABLE AS WE GO TO PRESS.)

The differences between actual production and the product of the trend and the synthesis (actual minus forecast) in millions of pounds, and in percentage deviations from forecast times trend are as follows:

1948	.6	or	00.1%
1949	-2.1	or	-00.4%
1950	66.0	or	11.8%
1951	10.4	or	01.6
1952 (est)	-2.3	or	-00.4%

Remember that the production for 1948 was known when the forecast was issued. Remember too that the trend given here was determined after the fact. The trend as you or I might have determined it in 1949 would doubtless have been slightly different, and in truth, the trend may ultimately prove to be slightly different from the values given here; no one can tell until time unfolds. I cannot see that in any case the differences would be enough, one way or the other, to be very important percentagewise.

The synthesis in percentages for these years and the actual behavior as a percent of trend are shown in Fig. 1 below by means of broken and solid lines respectively. The combination of cycles and trend compared with actual production is shown in Fig. 2.

The percentages that these production figures are of the estimated trend, the percentages that were used in the forecast made as of the end of 1948 (no 1949 figures being available when it was made), and the error, is shown below:

YEAR	ACTUAL PRODUCTION AS PER CENT OF TREND	PERCENTAGE CALLED FOR BY THE FORECAST	ERROR PERCENT EXCESS: ACTUAL OVER FORECAST TAKEN AS 100%
*1948	99.6	99.5	00.1
1949	93.4	93.8	-00.4
1950	105.2	94.1	11.8
1951	108.5	106.8	01.6
1952	94.0	94.4	-00.4

It is obvious that the firms which bought this report when it was issued were forewarned of the possibility of poor business in 1949, of exceptional good business in 1951, and of poor business in 1952. From this sort of a study, however, they could not have been forewarned of the good business that came as a result of the Korean War in 1950, nor of whatever good business may have flowed from the war in 1951.

Cycle projections should be revised at frequent intervals to true them up to actuality. This projection has worked very well for the four years 1948—1952 but unless revised, it should not be expected to work as well for 1952—1956, and unless revised again it will probably work still less well for 1956—1960. Those who wish all the light which it is possible for a knowledge of cycles to throw upon the future of rayon production should therefore revise the forecast from 1952 forward by means of the methods described in the report referred to above.

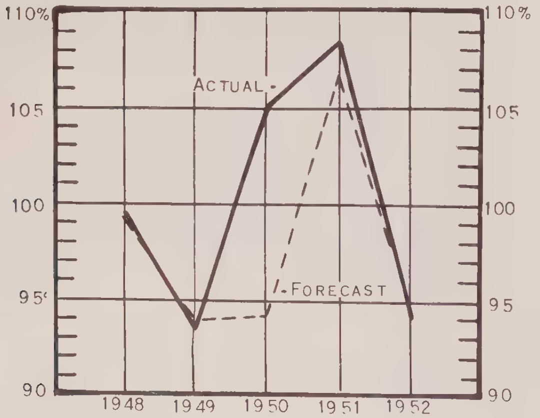


FIG. 1--VISCOSE RAYON FILAMENT YARN PRODUCTION
PERCENT OF TREND

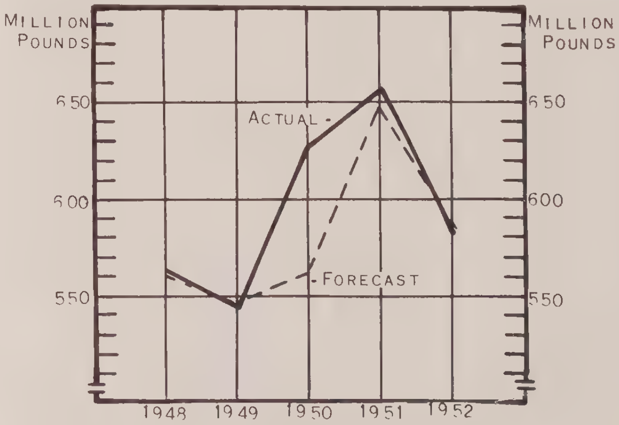


FIG. 2--VISCOSE RAYON FILAMENT YARN PRODUCTION
MILLIONS OF POUNDS

Letters

Correspondence With Eugene E. Reitz

Dear Mr. Dewey:

Like many of the members, I am accepting the opportunity to express a few opinions and ideas about the Foundation's work and reports.

I feel that most of the suggestions made by Mr. Michael Modell in his letter published in the September issue may express the feelings of a number of members interested in the study of cycles and their practical application.

[Mr. Modell suggested (1) a directory of members, (2) a textbook of statistical methods useful in cycle analysis, and (3) the possibility of special voluntary assessment of those among the membership who might be interested in the development of some special study. Ed.]

Investigate Short-Term Swings

I would also like to see some research made in short-term swings, especially in commodities. It is my opinion that commodity prices, such as cotton or soy beans, especially the latter, offer a much better subject for short-term study than a particular stock. Commodities offer cycles which occur more frequently with moves that are sharper, more clear-cut, with turning-points almost upon the day. Cycles of shorter length can usually be detected even in their periods of consolidation or accumulation, whereas stocks seem to operate in a more undecided trend with broader tops and bottoms, giving too much chance of fitting in a non-existing cycle when movements and dates of trend-change are not very pronounced.

Nelson's Work Praised

I can easily say that of the reports I have read up to the present time, I found the article by John H. Nelson, of R. C. A., Inc., in the March issue of this year, to appeal to me the most. The methods used by Mr. Nelson, or I should say methods very similar, can offer some interesting possibilities, especially in charting, I shall say mass emotions. Research, to a certain extent, has not been lacking along these lines and some of the best results along economic lines, that I have seen up to now, have been produced by the use of similar methods. Of course, as in many things there are the amateurs of great confidence and small knowledge whose works many times find their way in print and fail to justify a system's possibilities.

As in the study of fixed cycles, the planetary method needs much study—the subject and possibilities are broad. There is one thing that we can never be quite sure of. It is this: Can we ever know that the finer points that would make this method or any other a science, have not been discovered more than once in the past? We all know that any discovery of pronounced value in its application to markets, would never reach print, I have only a suspicion that this might have been accomplished, even as far back as the fifteenth century. For us, though, it is a matter of beginning at the beginning and I think that it is impossible for anyone to study cycles for any length of time without coming to the conclusion that he is on the right track but for practical purposes, much polishing is necessary and that it will take more than the mind of one individual, working separately, to make any worth-while progress. An organization such as the Foundation is in a good position to assimilate the many ideas and do the enormous amount of checking necessary.

Study Cycles in Nature

I am hoping that in the direction of your research you will not over-look the great possibility of nature in producing cycles in all things, also reflecting them perhaps in a terrestrial manner. If this is false reasoning then I shall say that there has been an awful lot of smoke eminating from an awful lot of literature of the past, without a fire to start it. In the light of present knowledge of planetary cycles, one familiar with these methods does not wonder about the many successes but about the occasional failures, and especially the lack of knowledge in applying to individual and specific things. How it is that some things after following the trend for a long time will break from the herd, so to speak, with something else coming back in line about this time. A great amount of work would be necessary in attempting to break these cycles down to apply individually instead of collectively as in the form of an average but I believe this to be possible.

In event enough response is received in regard to research upon a particular stock or perhaps commodity I would be interested and appreciate being informed of any decision which may be under consideration.

Yours very truly,
Eugene E. Reitz

El Campo, Texas

In reply I said:

Dear Mr. Reitz:

I found your letter of great interest.

Two or three other people have responded to Mr. Modell's suggestion that a group of people chip in to finance a cycle study for some particular stock, but I don't believe that the aggregate amount of money that these people would be willing to put up would make a dent on a comprehensive stock market analysis.

I would estimate that such an analysis might cost as much as $25,000.

With the number that have responded, this would mean about $5,000 apiece.

If anything of this sort were to be done, I think your idea of making a study of commodity prices has a great deal of merit.

In regard to the article by Mr. Nelson, you will be glad to know that Mr. Nelson has provided me with the actual dates over a period of years of the planetary configurations that correspond to changes in radio weather. I asked Mr. Nelson for these dates so that people such as yourself could compare them with dates of turning points in series of figures in which they are interested. I shall publish these dates just as soon as space permits.

I fully agree with you about the desirability of studying cycles in natural science as distinct from social science. If I were a completely free agent, I would devote a large share of my energies to the study of cycles in sunspot numbers, the thickness of tree rings, and the thickness of sedimentary rock deposits.

There are two marvelous phrases in your letter that should be printed in bold face type: "**.. amateurs of great confidence and small knowledge...**" and "**..it will take more than the mind of one individual, working separately, to make any worth-while progress.**"

I appreciate your letter and find myself in complete accord with your point of view.

Very cordially yours,

Correspondence With Stephen W. Gray

Dear Mr. Dewey:

I have seen much discussion of cycle analysis in your monthly **Reports**, and I wonder if your readers would be interested in a convenient method for obtaining periodograms. It is one I have used for some time with good results.

New Method for Making Periodograms

If the data be put on adding machine tape in a single column (a typewriter will do this as well) they can be readily analyzed by making the following simple instrument.

A book is made by stapling together as many sheets of (in my case) brown paper as there are cycle lengths to be tested. The first sheet is three inches wide and each subsequent sheet is one inch wider than the last. In the exposed edge of each sheet holes are punched to show certain figures on the tape. For example, the first page has holes to show every third figure, the second to show every fourth and so forth (to every 40th term in my book). The tape is placed behind the page with the first term under the first hole. All of the figures showing in the punch holes are added without danger of getting out of place. The tape is then slipped up one term and the second set added. This is repeated until each set has been added.

A Time Saver

The method saves the writing of the whole set of terms in three, four, five, etc. columns each time, and will be a great time-saver where several series of terms are to be tested.

I might add that I have found your reports of great interest and much use to me.

Yours truly,
Stephen W. Gray

Anatomy Department,
Emory University,
Emory University, Georgia.

In reply I said:

Dear Dr. Gray:

May I print your recent letter?

Your scheme is very ingenious and would, I should think, be a tremendous time-saver where one can get along with periodic tables of an integral number of days, weeks, months, years, etc. The trouble is that such tables are nowhere nearly close enough to each other in wave length to be of much use. That is, if you had 3½-month waves, for example, neither a 3-month periodic table or a 4-month periodic table would reveal it. The crest would slip one way or the other half a cycle every line and would be completely washed out in six or eight cycles depending upon whether you were using a 3-month periodic table or a 4-month periodic table.

Similarly, even a 3.1-month wave would completely vanish in 30 or 40 cycles.

I suppose your book could be made to cover all possible lengths but as one rarely needs all lengths I wonder if it is not easier to make up tables in the old fashioned way except for a complete multiple harmonic analysis? But if one is going to make a complete harmonic analysis I imagine machine operation would usually be preferable for preliminary purposes, if one could get hold of a machine.

If your book is long enough to accommodate the entire adding machine strip it would permit you to throw out the highs and lows of each column so as to obtain the average median instead of the mean. This should always be done to eliminate accidental distortions as much as possible. One disadvantage in your method is that it does not permit the use of color in the periodic table. I find the use of color a very desirable adjunct as explained in an article on pages 179 and 180 of our report for May 1951.

In spite of these limitations I think your method is very ingenious and can doubtless be used by many of our members in constructing periodic tables in those instances where it is applicable.

Thank you for bringing it to my attention.

Cordially yours,

Dear Mr. Dewey:

You may certainly publish my letter of September 23, if you care to.

I might add that your remarks are certainly justified and that if one is looking for fractional cycles one may easily lose them. In my case, I was looking for rather long cycles which probably showed up well enough as my data were not intrinsically accurate enough to worry about such fine points. I suppose that each of us invents methods for the particular problem.

The "book" makes machine work easier but actually most of the time I did not have the use of a machine at all!

Perhaps I shall have a paper for you if I find time to work on it.

Sincerely,
Stephen W. Gray

Additions to the Library

"Population Cycles and Color Phase Genetics of the Colored Fox in Quebec," by L Butler. Reprinted from **Canadian Journal of Zoology**, 29 :24-41, February 1951, 18 pages, 3 tables, 6 figures, references. Gift of the author.

Dr. Butler is Assistant Professor of Genetics at the University of Toronto.

Dr. Butler finds nine-year cycles and four-year cycles existing simultaneously in colored fox population data.

"The primary causes," he says, "are not within the animal itself but rather within the environment in which it breeds and raises its young. Thus a fox breeding south of the timberline will tend to conform to the nine-year cycle but the same fox breeding north of the timberline will tend to conform to the four-year cycle. Migrations will correspond in cycle with that in the area from which they emigrated." This is a good paper.

● ● ●

"Concerning Fluctuations in Populations of the Prolific and Widely Distributed Muskrat," by Paul L. Errington, Iowa State College, Ames, Iowa. Printed in **The American Naturalist**, Vol. LXXXV, No. 824, September-October, 1951, 20 pages, references. Gift of the author.

Dr. Errington is Research Professor at Iowa State College.

In this interesting paper he devotes about eight pages to the so-called 10-year cycle in the abundance of muskrat. In discussing this cycle Dr. Errington states: "... my feeling is that something still unknown may be more of a master factor [than drought or forest growth following fires] behind the 'classically cyclic' fluctuations of the species."

Later he says, "My concept of an unknown factor underlying the apparent synchrony of 'cyclic' manifestations is of something depressing certain life processes. Apparently, it may be far more nearly a master factor in determining abundance of some species than of others, but, on the basis of the evidence in sight, I would suspect that animal life generally may be subject to its influence, even if not to the extent of appreciably fluctuating in numbers. Years ago, in my gropings concerning possible mechanisms, I judged that essentially all the manifestations I had been classing as 'cyclic' **could** reflect overstimulation followed by exhaustion....

"My interpretation of the evidence from the muskrats is that stress has repeatedly accompanied both the attainment of top-heavy populations whenever occurring and the onset of 'low cycle' years, whether the species were particularly abundant or not. There still appears to be something about the chronological 'cyclic low,' that is, the years of late decades ending in sixes and/or sevens in the north-central region, 'to cause moderate or even low populations to display the symptoms that we associate with overpopulation.

"Despite the philosophical hazards and the lack of satisfaction of attempting to explain one unknown in terms of another, I do not see how we may, with scientific propriety, ignore the synchronies of symptoms that have gradually emerged from detailed population data."

● ● ●

"The Art and Science of Prediction," by LCDR. David Williams, 9 pages. Gift of the author.

Commander Williams (Consolidated Edison Company, New York City) offers free copies of this paper to members—while the supply lasts.

"Precipitation and Temperature in Washington, D.C., for 1951 and 1952," by C. G. Abbot, Smithsonian Institution of Washington, March 18, 1952, Smithsonian Miscellaneous Collections, Volume 117, Number 9, 5 pages, 3 tables, 2 figures, Gift of the author.

"Periodicities in the Solar-Constant Measures," by C. G. Abbot, Smithsonian Institution of Washington, May 28, 1952, Smithsonian Miscellaneous Collections, Volume 117, Number 10, 31 pages, 7 tables, 6 figures. Gift of the author.

"Important Interferences With Normals in Weather Records, Associated With Sunspot Frequency," by C. G. Abbot, Smithsonian Institution of Washington, May 20, 1952, Smithsonian Miscellaneous Collections, Volume 117, Number 11, 3 pages, 1 figure. Gift of the author.

Dr. Abbot, as you doubtless know, was formerly head of the Smithsonian Institution of Washington.

These three papers will be reviewed in a future report.

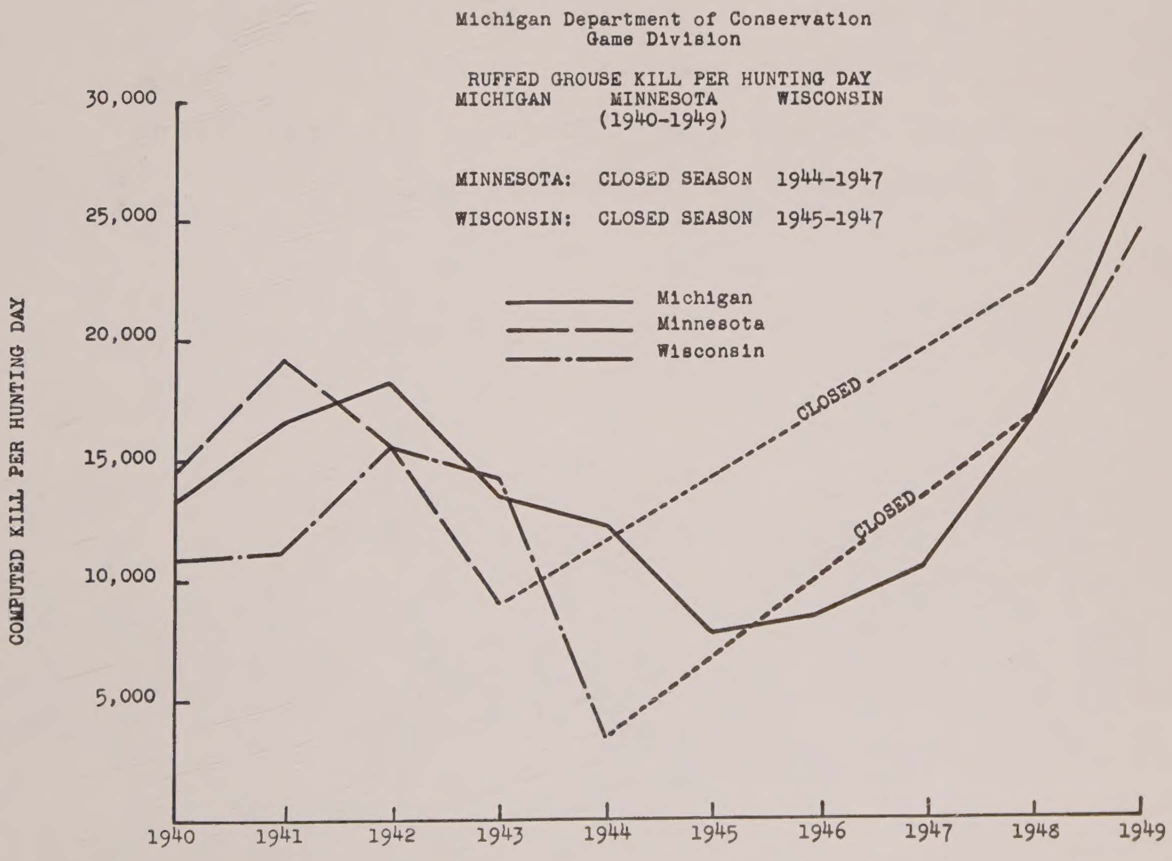
These are all important papers. Dr. Abbot considers No. 10 to be his magnum opus.

In the meantime, I imagine that any of you who are interested can obtain free copies of any or all of these reports on request from the Smithsonian Institution, Washington, D.C.

• • •

"Closed Season No Boon to Ruffed Grouse," by Arnold B. Erickson. Reprinted from **Conservation Volunteer**, January-February 1951, 3 pages, 1 chart, Gift of Dr. Erickson.

Dr. Erickson, who is Game Biologist, Division of Game and Fish, Minnesota Conservation Department, shows that open partridge seasons during cyclic lows appear to be harmless. See chart below:



Summer Fellowship For A Professor

Money is available to enable a member of the teaching staff of a senior college in the United States or abroad to study cycle analysis at Foundation Headquarters at East Brady, Pennsylvania, during the summer vacation of 1953.

If you are interested in this opportunity, write to the Director, Foundation for the Study of Cycles, East Brady, Pennsylvania.